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ABSTRACT

The papers included here are based on a 1971 symposium held at the annual meeting of the Western Psychological Association in San Francisco. The first three papers report the results of research carried out over the last few years at the Wisconsin Research and Development Center for Cognitive Learning. Levin's paper focuses on the effectiveness of verbal and imaginal cognitive strategies, and their development with age. Wolff's paper summarizes research in which the developmental course of imagery production is tied to the early sensorimotor activity of the young child. Davidson examines the relationship between imagery and language processes in the child, and the broader question of whether imagery is inextricably linked to meaning. Rohwer's paper deals with the difficult-to-determine task and population validities for supposedly easy-to-determine phenomena. (Author)

ISSUES IN IMAGERY
AND LEARNING:
FOUR PAPERS

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Theoretical Paper No. 36

ISSUES IN IMAGERY AND LEARNING: FOUR PAPERS

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Statement of Focus

The Wisconsin Research and Development Center for Cognitive Learning focuses on contributing to a better understanding of cognitive learning by children and youth and to the improvement of related educational practices. The strategy for research and development is comprehensive. It includes basic research to generate new knowledge about the conditions and processes of learning and about the processes of instruction, and the subsequent development of research-based instructional materials, many of which are designed for use by teachers and others for use by students. These materials are tested and refined in school settings. Throughout these operations behavioral scientists, curriculum experts, academic scholars, and school people interact, insuring that the results of Center activities are based soundly on knowledge of subject matter and cognitive learning and that they are applied to the improvement of educational practice.

This Theoretical Paper is from the Program on Variables and Processes of Learning and Instruction. General objectives of the Program are to generate knowledge about concept learning and cognitive skills, to synthesize existing knowledge and develop general taxonomies, models, or theories of cognitive learning, and to utilize the knowledge in the development of curriculum materials and procedures. Contributing to these Program objectives, this project has these objectives: to ascertain the important variables in cognitive learning and to apply relevant knowledge to the development of instructional materials and to the programming of instruction for individual students; to clarify the basic processes and abilities involved in concept learning; and to develop a system of individually guided motivation for use in the elementary school.

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Abstract

The papers included here are based on a 1971 symposium held at the annual meeting of the Western Psychological Association in San Francisco. The first three papers report the results of research carried out over the last few years at the Wisconsin Research and Development Center for Cognitive Learning. Levin's paper focuses on the effectiveness of verbal and imaginal cognitive strategies, and their development with age. Surprisingly, the age variable represents a relatively recent consideration in experiments in which subjects are required to generate their own dynamic visual representations. Wolff's paper summarizes research in which the developmental course of imagery production is tied to the early sensorimotor activity of the young child. Davidson examines another theoretical issue: the relationship between imagery and language processes in the child, and the broader question of whether imagery is inextricably linked to meaning. Rohwer's paper deals with a recurring theme in imagery research, namely the difficult-to-determine task and population validities for supposedly easy-to-demonstrate phenomena. He documents the fact that well-established findings based on one set of operations may not be extended easily to tasks involving different materials or to demographically different populations.

I

When Is a Picture Worth a Thousand Words?¹

Joel R. Levin

The above title was selected to imply that the conditions under which a pictorial representation of learning materials (either externally supplied to, or internally supplied by, a learner) is facilitative are not yet well known. In this paper, attention will be paid to the question of differing modes of representation with an eye toward:

1. Differentiating among paradigms that have typically been employed to assess the mnemonic facilitation of learning,
2. Relating some of the research involving verbal and pictorial mnemonics, and
3. Providing occasional hints regarding the ontogenetic development of efficient mnemonic strategies in children.

Many of the arguments to be made are based on learning tasks which ostensibly tap gross memory (free recall): e.g., Bower, Lesgold, and Tieman (1969); Irwin, Gerdes, and Rohwer (1971); and Jensen and Rohwer (1970) as well as those which require sequential memory (serial): e.g., Bower and Clark (1969); Levin and Rohwer (1968); and Simpson (1965). However (quite possibly for reasons alluded

to below), tasks which call upon associative memory (paired-associate) are enduring love-objects of contemporary researchers; e.g., Paivio (1971); *Psychological Bulletin* (1970); and Rohwer (1967).²

To refresh the reader's memory, a paired-associate task consists of a collection of discrete item pairs, presented successively to the learner. The discrete nature of the pairs is important, since unlike free recall and serial tasks, gross memory and sequential memory are less important as far as successful paired-associate performance is concerned (at least in paired-associate tasks where presentation order is randomized, and certainly when a recognition method of testing is used). The learner must, instead, focus on each pair as a separate unit, with the success of his performance (as usually defined by recognition or recall of the second member of each pair--the response term--upon presentation of the first pair member--the stimulus term) dependent upon the degree to which stable associations within pairs are generated. It is this feature of within-pair associations which lends itself especially well to the independent manipulation of physical and psychological properties of paired-associate materials.

Most of the empirical findings are based on just such between- and within-subject manipulations of "imagery" in paired-associate

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²These different kinds of memory were chosen for convenience only, and not to imply that the requisites of the respective tasks are mutually exclusive. It should be clear that each of the three tasks includes (as a minimum) components of gross and associative memory.

learning. For example, Paivio and his associates (Paivio, 1969) have systematically varied concreteness both between pairs (i.e., pairs which are highly concrete and image evoking vs. those which are not) and within pairs (i.e., the concreteness of the stimulus and response terms is varied independently). An extreme comparison along this dimension involves the use of picture and word pairs (Rohwer, Lynch, Levin, & Suzuki, 1967a) or the factorial manipulation of words and pictures as stimulus or response terms (Dilley & Paivio, 1968; Paivio & Yarmey, 1966). Study-to-test-trial variations in the mode of stimulus materials are also possible (Lynch & Rohwer, 1971; Wicker & Evertson, 1971), as is the mode in which learning is assessed: recognition of words or pictures; or recall of words (oral or written) or pictures (construction or representation).

Apart from the physical properties of the to-be-associated items, manipulations of semantic and syntactic properties of the materials, including the mediational link between the paired associates, have been extensively investigated (e.g., Rohwer, 1967). Such variables as the meaningfulness (Rohwer, 1966) and appropriateness (Rohwer & Levin, 1968) of the structure imposed on the materials; the nature of the subject-object relationship (Ehri & Rohwer, 1969; Suzuki & Rohwer, 1968); and word meaning in original learning (Levin & Horvitz, 1971) and transfer (Davidson, Schwenn, & Adams, 1970) have all been studied. On the basis of this kind of research one resounding conclusion is evident: paired-associate tasks (especially those in which the materials consist of meaningful or familiar, as opposed to nonsense or unfamiliar, items) pose anything but pure rote-learning situations for learners who are mature enough to use or generate efficient associative strategies. This statement runs counter to the popular notion that paired-associate tasks are convenient measures of what Jensen (1969) has termed "Level I" learning ability. To the contrary, there is an increasing amount of evidence that paired-associate performance correlates substantially with tasks which are generally regarded as conceptual, or which require cognitive transformations of stimulus input, as defined by "Level II" abilities (Jensen & Rohwer, 1970; Stevenson, Hale, Klein, & Miller, 1968).

Verbal and Pictorial Facilitation of Paired-Associate Learning

The foci of research into the imagery and

learning domain in recent years may be identified simply in terms of one (or a combination) of the four cells in Figure 1. As may be seen in Figure 1, the two columns are represented by a "nature of strategy" factor, while the two rows consist of what might be called a "method of strategy evocation" factor. By "strategy" is meant a method or manipulation which facilitates learning.

		Nature of Strategy	
		Verbal	Imagery
Method of Evocation	Imposed		
	Induced		

Fig. 1. Simplified representation of the combinations of variables typically investigated.

Most of the work in imagery and learning has been concerned with various verbal and pictorial representations which are "imposed" on learners. Imposed verbal strategies include experimenters' manipulations of semantic and syntactic properties of learning materials, some of which were already described. Imposed imagery strategies are those in which characteristics of the learning materials are made more or less imageable along either a concreteness-abstractness, or a dynamic-static, dimension.

The effect of induced strategies has also been studied in a number of experiments. In these, a strategy is "induced" in learners prior to learning, in the form of an instructional set supplied by the experimenter. Unlike the imposed strategy studies, here the learner is not provided with differing representations of particular items, but rather with a general set to generate his own verbal or pictorial mnemonics which hopefully will facilitate the task. It should be added that with both the imposed and induced techniques, the actual mode of stimulus encoding by the learner is at best

inferred. That is to say, the techniques adopted are designed to encourage, but not guarantee, particular modes of stimulus input. Whether or not the researcher's expectations are confirmed may only be inferred at the present time, although some exciting methodological and technological advances (e.g., Brooks, 1968; Pribram, 1969) promise to reduce the uncertainty.

The imposed-induced distinction is an important one to make, since researchers frequently tend to gloss over or ignore this dimension when it comes to interpreting mnemonic effects (see Rohwer, Section IV). There is a tendency to group together into one mnemonic "bag" data from studies based on the two paradigms which, if not attended to, occasionally lead to contradictory conclusions. One of the purposes in identifying this dimension here is to induce the reader to consider the different requisites for generating, as opposed to using, learning strategies.

Admittedly, Figure 1 is oversimplified. "Procedural" and "content" variable dimensions (Jensen, 1967) could certainly be added. What is intended by this simplification is a mapping out of the vast mnemonic "battlefield" before proceeding to inspect the corresponding "artillery."

Imposed Verbal and Imagery Strategies

Much is known and continues to be investigated with regard to the effect of strategies imposed on subjects by experimenters. For example, the comparative ease with which a variety of stimulus materials is learned has been demonstrated through several independent experiments and replications. An overview of the basic research findings is presented in the imposed "tree" diagram of Figure 2. If the height of each branch reflects a greater degree of facilitated learning, then as one climbs downward through the respective verbal and imagery branches of the tree, one will uncover an easiest-to-hardest hierarchical arrangement.

Piecing together the available evidence concerning the learning of verbally presented word (noun) pairs, it is fairly well established that: (a) concrete noun pairs embedded in meaningful English sentences are more easily recalled than (b) the same noun pairs embedded in prepositional phrases, which in turn are better recalled than either (c) concrete noun pairs embedded in conjunctive phrases or concrete noun pairs with no accompanying context, which in turn are easier to learn than (d) abstract noun pairs, and which in turn are (pre-



Fig. 2. The imposed verbal-imagery facilitation tree.

sumably) easier to recall than (e) paired nonsense syllables (Goss & Nodine, 1965; Paivio, 1969; Rohwer, 1967; Rohwer et al., 1967a).

On the imagery side of the tree are displayed the various forms in which nonverbal learning materials typically have been presented. Each is hierarchically arranged according to its respective ease of acquisition. Thus: (a) animated pairs of familiar objects involved in a dynamic interaction are easier to associate than (b) the same pairs involved in a static interaction, which in turn are more easily learned than (c) familiar objects placed adjacent to one another, which in turn are easier to learn than (d) pictures of the adjacent object pairs, and which in turn are (presumably) easier to recall than (e) pairs of unfamiliar picture pairs (Iscoe & Semler, 1964; London & Robinson, 1968; Rohwer, Lynch, Suzuki, & Levin, 1967b).

Cross-branch comparisons have also been made in the form of comparing verbal vs. pictorial facilitation (e.g., Davidson & Adams, 1970; Kee, Guy, & Rohwer, 1971; Milgram, 1967; Rohwer et al., 1967b) and words vs. pictures (e.g., Dilley & Paivio, 1968; Lynch & Rohwer, 1971; Rohwer et al., 1967a), among others.

Moreover, within-tree comparisons involving subjects from different intelligence, social class, and age groups have received some attention, and are summarized elsewhere (e.g., Rohwer, Section IV; Rohwer, Ammon, Suzuki, & Levin, 1971; Rohwer & Levin, 1971). Note that the verbal and imagery branches are at the same height within each level of the hierarchy. This is not meant to imply that each is equally facilitative, but rather that it is difficult to order appropriately the cross-branch comparisons since verbal-imaginal differences may not be monotonic across levels of the population variables just listed.

While the facilitation tree is based on imposed learning strategies, a similar hierarchy may be posited—though not as readily documented—for induced strategies. The remainder of this paper proceeds in this direction, with particular attention paid to the developmental course of imagery generation.

Induced Imagery and Age

It has recently been suggested that the ability to benefit from imposed pictorial interactions increases with age (Reese, 1970; Rohwer, 1970). Reese has noted, as one plausible explanation of this, that the young (preschool) child typically does not "read" the information that is conveyed by a picture in which two objects have been related spatially to one another. Horowitz, Lampel, and Takanishi (1969) present data which strongly support Reese's assertion.



Fig. 3. Example of an imposed imaginal interaction.

For example, upon inspecting the interaction depicted in Figure 3, the reader undoubtedly will "read" it for what it is, i.e., a cat "nibbling" on an apple or some such related activity. A young child, when shown the same picture, can certainly perceive and identify

the objects. However, assuming that he labels the two objects, it will be of the form "A cat and an apple" or "The cat and the apple" rather than "The cat bites (is eating) the apple." Thus, he has "misread" the intended relationship or story. Whether the accompanying verbal statement is in fact a necessary concomitant of imagery mediation has been thoroughly discussed by Bower (1971). What is of importance, however, is that the relationship contained in the picture and the child's encoding of it probably constitute a mismatch. If a reasonable relationship between stimulus and response items must be perceived in order for paired-associate learning to be facilitated—as Bower (1971) and others have argued—then the young child will not profit as much from interacting paired associates as will the older child. This, of course, is exactly what the data reveal (Horowitz et al., 1969; *Psychological Bulletin*, 1970). At the same time, sentence descriptions provided by the experimenter to render the interaction more salient are more facilitative for the younger, as compared with the older, child (Rohwer, 1970).

Despite a greater imposed imagery effect for older than for younger children, it should be remembered that interacting pictures facilitate the learning even of four-year-olds (*Psychological Bulletin*, 1970). The same statement cannot be made with regard to induced imagery effects. While Bower (1971), Bugelski (1970), Paivio (1971), and others attest to the potency of an imagery instructional set induced in adult subjects, except for a handful of experiments the efficacy of induced imagery has not been seriously considered in studies involving children.

As will be seen in a following section, the results of such studies have been somewhat conflicting and limited by variations in procedures and materials. For example, Taylor and Black (1969) found that sixth graders who were given imagery instructions to associate printed word pairs (i.e., "Think of a picture in your mind of the two things in each pair doing something together") performed only slightly better than non-imagery controls. This finding has been replicated by Levin and Kaplan (in press). However, in the latter study, when static line drawings were substituted for the printed words, the imagery strategy was so facilitative that there was no overlap in the score distributions of imagery and control subjects.

Whopping imagery-control differences were also detected in an experiment with sixth graders (Taylor, Josberger, & Prentice, 1970) in which the investigators employed a more complicated paired-associate task (involving a single stimulus word and three response terms per item),

an extensive training procedure (which capitalized on the fading of imposed imagery prompts from one example to the next), longer than usual study- and test-trial intervals (20 seconds and 15 seconds, respectively), and a repetition rehearsal control condition to prevent the child from spontaneously mediating (see Bobrow & Bower, 1969).

Spiker (1960), using fifth graders, found that previous instruction in self-generated imagery was helpful in overcoming negative transfer. During List I learning, a verbal description of the interaction to be imaged (an imposed verbal strategy to induce imagery) was provided by the experimenter for each pair. Imagery-control differences were smaller in earlier stages of List II learning than in later.

Rohwer and Ammon (1971) investigated the possibility of training second graders in the use of mnemonic strategies, but with only minimal success. After supplying their experimental subjects with a barrage of mediational techniques (one of which was induced imagery) during a week's worth of practice, only a small degree of facilitation was observed, relative to untrained controls. In a subsequent unpublished study by Rohwer, in which four- and five-year-olds were similarly trained, no training effects were detected.

In order to make a more direct assessment of the effectiveness of induced imagery strategies in children, Bob Davidson, Peter Wolff, Michelle Citron, and I tested second and fifth graders under various conditions. Although more will be said about this study later, the major finding was that children in both grades benefitted from induced imagery instructions, with the effect statistically more pronounced for fifth graders. At the same time, Montague (1970) has reported negligible induced imagery-control differences in a lower class first-grade sample, while finding that an imposed imagery strategy was facilitative.

On the basis of the data reported thus far, it would seem that the ability to generate dynamic visual images—or perhaps, to make effective use of them once generated—develops over the elementary school years. Such an ability emerges later developmentally than does the ability to use provided (imposed) imagery strategies, thereby corroborating the distinction between "production" and "mediational" deficiencies (cf. Flavell, in press) in the imagery, as well as the verbal, domain.

The fact that imagery production may be "induced" under certain conditions is of special interest. In a recent series of experiments elaborated upon by Wolff (Section II), children too young to generate dynamic visual images on

request constituted the target population. In one study (Wolff & Levin, in press), kindergartners were compared with third graders in their ability to generate interactions involving pairs of toys. Using ordinary imagery instructions, third graders far outperformed non-instructed controls. Kindergartners did not. On the other hand, when kindergarten children were permitted to generate motoric interactions involving the toys (i.e., they were allowed to manipulate the toys), their performance was also facilitated. Since this was true even under conditions in which the children were denied visual access to their manipulations, strong support was provided for the Piagetian notion that at this age the child's imagery is realized through his manipulative activity.

Induced Imagery vs. Induced Sentences

As was indicated previously with regard to the tree represented in Figure 1, a comparison of verbal and imagery imposed strategies has been made at various age levels. A few investigators have compared verbal and imagery induced strategies in adults (e.g., Bower & Winzenz, 1970; Paivio & Foth, 1970; Yuille & Paivio, 1968).

The general findings indicate that adults benefit slightly more from induced imagery than induced phrase/sentence instructions and, in particular, when the to-be-associated items are concrete. On the other hand, Montague (1970) has reported that while her first graders were unable to benefit from imagery instructions (as mentioned previously), sentence instructions were extremely facilitative, with children receiving the latter not differing significantly from those in imposed sentence and imagery conditions. What makes Montague's (1970) result all the more intriguing is that it complements that of a developmental study by Jensen and Rohwer (1965). In that experiment, kindergartners were not helped by sentence instructions, probably because "...many of them were unable to construct sentences on call..." (Jensen & Rohwer, 1965). Yet in their second grade sample, Jensen and Rohwer found differences between sentence and control subjects that were larger than at any other grade investigated (4th, 6th, 8th, 10th, and 12th).

Piecing together the various data suggests that the emergence of subject-generated sentence mnemonics as facilitative learning strategies may closely approximate the emergence of subject-generated dynamic imagery, the former preceding the latter by perhaps a year.

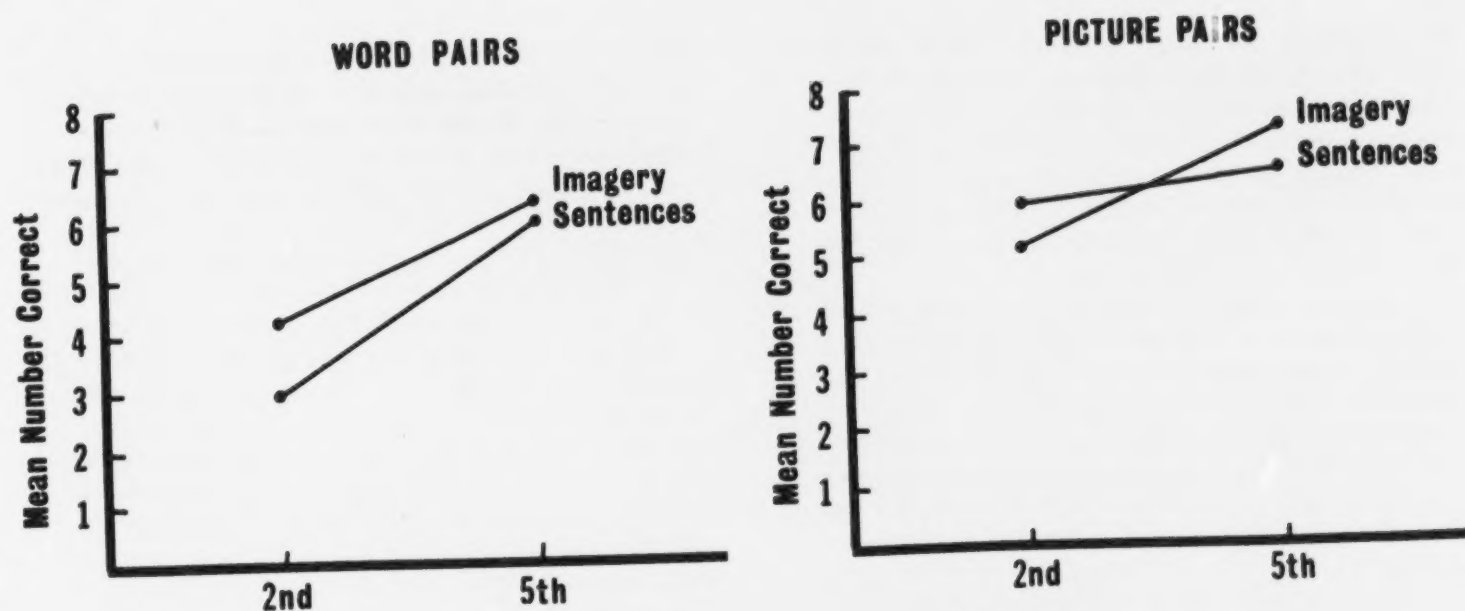


Fig. 4. Data from a study comparing imagery and sentence instructions at two grade levels with two types of materials.

Thus, at age five neither type of induced strategy facilitates learning (Jensen & Rohwer, 1965; Rohwer, 1967; Wolff & Levin, in press). Whether or not sentence production can be successfully induced at this age through concurrent motoric involvement, as has been demonstrated for imagery production (Wolff & Levin, in press), is currently being investigated. At age six, subject-generated sentences appear to facilitate learning while subject-generated imagery does not (Montague, 1970). Finally, within a year or so, both types of induced strategy are facilitative (Jensen & Rohwer, 1965; Wolff & Levin, in press), with imagery developing into a slightly more efficient strategy in adulthood (Bower & Winzenz, 1970; Paivio & Foth, 1970).

In order to compare the respective developments of subject-generated sentence and imagery mnemonics in children, we pitted the two against one another at two grade levels: second and fifth. In addition to the induced strategies just mentioned, two additional instructional conditions were included: a control (uninstructed) condition, and a condition where subjects were given both imagery and sentence generation instructions. It should also be pointed out that the sentences generated by Ss were covert (never uttered aloud) unlike those in some of the studies already reported.³

³The "overt-covert" distinction may well be important, especially for younger children, and is at present being considered in reference to the Montague (1970) data.

On the basis of imposed sentence versus imagery data, it was predicted that sentence instructions would be relatively more facilitative (compared to imagery instructions) for second graders; but that imagery instructions would catch up with or surpass sentence instructions in the fifth grade sample (Rohwer, 1970). It was also anticipated—if the parallel between imposed and induced strategies holds—that two doses of elaboration (imagery plus sentences) would be more facilitative than just one (see Rohwer, 1967).

Table 1
Data from a Study with Second and Fifth Graders, Comparing Four Different Types of Instructions (Mean Percent Correct After One Study Trial)

Instructions	Grade	
	2nd	5th
Control	13%	20%
Sentence	55%	78%
Imagery	58%	84%
Imagery & Sentence	53%	72%

The results of this experiment may be found in Table 1, collapsed across two methods of testing (recall and recognition) and two types of material (word and picture pairs). Statistically, in both grades the three strategy groups each differ from the control, but not from one

another. The prediction based on the comparison of sentence and imagery instructions at the two grade levels was partially supported by the data, being qualified by the mode in which learning materials were presented (words or pictures). The form of this interaction is shown in Figure 4. For picture pairs, the reversal exhibited in imposed sentence vs. imagery studies (also using pictorial materials) emerges here. This effect does not differ statistically as a function of test method (recall or recognition), although it is descriptively more pronounced under recall. For word pairs, a positive imagery-sentence difference shows a descriptive decrease from second to fifth grade. This pattern does not interact with test methods either.

Another feature of Table 1 should be mentioned vis-à-vis the second prediction that two mnemonic strategies would be better than just one. While statistically not significant, the difference is in precisely the opposite direction at both grade levels. The notion of a "task overload" for the subject, as a result of his having been asked to employ a (complex) double strategy—especially in the study time allotted (four seconds)—may provide a reasonable account of these data and those in the Rohwer training studies. On the other hand, it just may be that the three different strategy instructions are similarly effective—especially when the small differences among them are contrasted with the large ones produced when each is compared with the control—and that, unlike the imposed results of Rohwer (1967), one strategy dose (whether sentential or imaginal) is sufficient to do the job. Such an interpretation is surely more parsimonious, and accords well with recent data (Mueller & Jablonski, 1970; Yarmey & Csapo, 1968) on adults.

It should be pointed out that while parallels between verbal and imaginal strategies have been drawn with regard to paired-associate learning, these inferences may be relatively task specific. For example, while it has been shown that serial learning is facilitated through the sentential organization of large groups of adjacent items (Bower & Clark, 1969; Levin & Rohwer, 1968), simply organizing consecutive items in a pairwise fashion is not facilitative (Jensen & Rohwer, 1965; Levin, 1970). On the other hand, instructions to generate imagery which relates consecutive items are facilitative (e.g., Delin, 1969a, b).

The experimental separation of verbal and imaginal learning strategies is not easy to achieve. In the studies of Milgram (1967) and Rohwer and Ammon (1971), no attention was paid to unconfounding the two. In the exper-

iment just reported, although the confounding is not so obvious since separate instructions to form sentences or images were incorporated, whether or not the strategies were "appropriately" encoded may only be inferred. A question of current interest and potential significance concerns the extent to which verbal and visual memory stores are functionally independent (Bower, 1970). By adopting the innovative technique of Brooks (1968), Atwood (1971) has selectively varied interference for relatively high- and low-imagery imposed materials. His conclusions that the two types of materials are processed by systems which deal primarily with pictorial-spatial and verbal-auditory information, respectively, are currently being appraised in situations wherein subjects are induced to process materials in one mode or the other. Thus, it seems entirely possible to discover whether subjects can, in fact, faithfully follow instructions to generate either imagery or verbalizations by determining whether there is an internal correspondence in the presumably separate encoding systems.

The empirical results of this section point up the developmental similarity between using and generating verbal and imaginal learning strategies. That is, it has been found that imposed imagery is initially less effective than imposed verbalization (for younger children), but that the former becomes more effective with increasing age. The same appears true for induced imagery versus induced verbalization. The ability to generate sentence mnemonics may develop about one year prior to the ability to generate dynamic visual images, the latter eventually serving as an equally effective, or even more effective, learning strategy.

Imagery and the Learning of Pictorial and Verbal Materials

It has been several years now since "hands inside bowls," "cats carrying umbrellas," and "cows chasing balls" have found their way into the psychological journals (cf. Davidson, 1964; Epstein, Rock, & Zuckerman, 1960; Reese, 1965; Rohwer, 1966). Yet what do we really know about the phenomenon that Rohwer (1967) has dubbed the "verbal elaboration" effect? To be sure, we can state that materials which are elaborated or organized verbally (through the addition of phrase or sentence contexts) are, in general, more easily learned than those which are not. At the same time, it is also well known that the magnitude of this facilita-

tion is largely a function of subject- and task-related variables (Rohwer, Section IV).

As was noted earlier, for example, children seem to profit more from elaborated materials or instructions to elaborate than do adults, since children are less likely to employ spontaneously efficient learning strategies. At the same time, this generalization may be more true of verbal than imaginal strategies, especially in middle class populations. A number of recent investigations suggest that while sentence elaborations tend to decrease in their effectiveness through adolescence into adulthood (Rohwer & Levin, 1971), imaginal elaborations continue to produce sizeable effects (Bower, 1971; Paivio, 1971).

The magnitude of the verbal elaboration effect also has been found to vary as a function of such variables as testing method, viz., recall vs. recognition (Rohwer, 1967); pacing rate (Rohwer & Ammon, 1968); the means by which elaboration is introduced, e.g., imposed vs. induced (Bobrow & Bower, 1969); semantic characteristics of the learning materials (Rohwer & Levin, 1968); as well as interactions among these variables. Moreover, several recent experiments employing printed materials have detected negligible (or in some cases, reverse) verbal elaboration effects (Davidson et al., 1970; Horvitz, 1971; Levin, 1970; Levin & Horvitz, 1971; Yuille & Pritchard, 1969).

Imposed Imagery

The same conclusion has been reached with regard to properties of pictorial (as well as pictorially-elaborated) materials. For example, while pairs of pictures are easier to remember than pairs of printed words, the magnitude of this difference varies with age (Dilleley & Paivio, 1968; Paivio & Yarmey, 1966; Rohwer, 1970). The picture-over-word main effect is certainly compatible with Paivio's (1969) arguments regarding the comparative ease with which more and less concrete/imageable materials are learned. That is, pictures are assumed to be more concrete and image-evoking than words, and in accordance with Paivio's (1965) research, materials high in I (rated imagery) are easier to learn.

The picture-word debates are not dead, however (e.g., Lynch & Rohwer, 1971). Bower (1971) has reported an effort to facilitate the learning of noun-noun pairs by making the stimulus nouns more like pictures or images. Bower reasoned that pictorial stimuli probably contain more incidental cues than word stimuli.

In a sense, all single-word stimuli are ambiguous in that they are unrestrictive with regard to plausible referents. Thus, the word "cat" is unspecific as far as its particular attributes are concerned. The feline pictured in Figure 3, on the other hand, leaves considerably less to the imagination.

In Bower's experiment, college subjects were shown either single-noun stimuli or three-noun stimuli (associatively related) in a noun-noun (or noun, noun, noun-noun) paired-associate task. The three-noun condition presumably provided incidental redundant cues (more like pictorial stimuli?), but contrary to Bower's expectations, the recall for this condition was worse (35% recall) than for the single-noun condition (48%).

A variation of this task is a "concretizing" procedure which Sandy Kaplan and I incorporated into a free recall study with first and sixth graders. Using adult subjects and printed word stimuli, Paivio and Csapo (1969) found that the picture-word difference obtains on paired-associate and free recall tasks, but not on serial tasks. The children in our experiment were asked to recall either a list of pictures or one of three lists of auditorily presented words (presented at a five-second rate): words preceded by an article; by an article plus an adjectival modifier; or by an article plus a subject nominalization of the type described by Paivio (1971). If unmodified words (e.g., a ball) are less concrete (and more ambiguous) than modified words (e.g., a round ball), which in turn are less concrete than nominalizations (e.g., a bouncing ball), this should be reflected in the free recall of the nouns.

No such effect was obtained in either the first grade or the sixth grade sample. I am further sorry to report—as was Bower (1971)—that the two modified word conditions were significantly worse than the picture condition. Equally as surprising was the finding that the picture condition and the unmodified word condition did not differ significantly from one another.

Perhaps the shorter exposure time accounts for the inferior performance of the modified word conditions, relative to the unmodified condition, as Bower (1971) has suggested. Perhaps, too, with explicit instructions to employ a visual imagery strategy, at least the sixth graders would have been helped in the two modified conditions. The differing picture-word effect in our experiment as compared with that of Paivio and Csapo (1969) may simply be related to the differing modes of presenting word stimuli. The abundant literature on the superior

short-term free recall of auditorily, as opposed to visually, presented verbal materials is of particular relevance (see Neisser, 1967). A quasi-replication of the experiment is being undertaken with these considerations in mind.

Induced Imagery

As was discussed earlier, the effect attributable to self-generated imagery strategies has been found to vary with age. In addition, there are data which suggest a possible three-way interaction involving imagery ability, age, and the mode in which learning materials are presented. Specifically, instructions to use visual imagery in a paired-associate task seem to be less facilitative when the materials from which subjects (especially children) are to initiate dynamic images are not highly concrete themselves. In the studies using children and printed materials, induced imagery effects have been quite small (e.g., Horvitz, 1971; Spiker, 1960; Taylor & Black, 1969). As has already been argued, it would be premature to account for these results by flatly stating that children at this age cannot benefit from imagery instructions, however.

In an experiment mentioned previously (Levin & Kaplan, in press), we found that 11-year-olds given imagery instructions did much better than control subjects in associating pairs of familiar pictures (static line drawings). On the other hand, when the learning materials consisted of verbal representations of the pictures (printed words), there was no significant imagery-control difference. A replication of the experiment revealed imagery facilitation for both picture and word pairs (descriptively greater for pictures than for words), but the "imagery for words" condition was accompanied by significantly greater variability in scores than the "imagery for pictures" condition. In neither study did the "imagery for pictures" scores overlap with those of their control group, while in both studies the "imagery for words" scores did. The results suggested that using imagery instructions with less concrete representations (i.e., printed words) was more difficult for children at this age than was using the same instructions with more concrete materials (i.e., pictures).

We have conducted a few subsequent experiments with elementary school children under mixed-list presentations. In these studies, the "imagery for pictures" and "imagery for words" effects have been more comparable, in terms of absolute score differences. However, the greater variability in performance for the

"imagery for words" items regularly appears.

The more potent instructional effect attributable to concreteness of the materials is not limited to pictorial representations. Horvitz (1971) found that for sixth graders, the same conclusion is reached when comparing sentence-embedded paired associates with conjunction-embedded paired associates in a mixed list. Imagery instructions were found to be relatively more facilitative for sentence-embedded pairs than for paired associates linked by conjunctions.

One could argue that sentences are probably more concrete representations than conjunctive phrases (by virtue of the concretizing function of the verb, the disambiguating of the pairs, the more meaningful rendering of them, and the like). If verb phrases are more concrete than conjunctive phrases, then the verbal facilitation phenomenon may be accounted for in Paivio's terms. Unfortunately, there are no hard data to support these speculations. That is, controlled imagery ratings of sentence and phrase materials (with selected semantic and syntactic variants) need to be obtained from both children and adults (see Davidson, Section III).

A hypothesis predicting the success of imagery instructions for materials of varying concreteness (e.g., word pairs, sentence-embedded word pairs, and picture pairs) fits nicely into an induced imagery flow chart proposed by Bower (1971) and reproduced here in Panel I of Figure 5. Bower's diagram has been formulated with printed word pairs as the learning materials, and thus, in order for imagery instructions to be facilitative, the learner must perform two transformations on the nominal stimuli during storage: one in which the words are encoded pictorially as separate images, and a second in which the two images are spatially related to one another. During retrieval, the cue word elicits the image of that word in interaction with the image of the response noun, which is finally decoded back into a verbal response.

Panels II and III of Figure 5 represent the corresponding process for sentence-embedded and picture pairs respectively, with a modification of the Bower diagram made in the final recall phase, in order to contrast the demands of recognition and recall testing formats. Added to Bower's word pairs in the first panel, the recognition-recall distinction would appear as in Panel II. More will be said about this later.

In contrast to word pairs, for both sentence-embedded and picture pairs it will be noted that one of the transformations required by the learner during storage has been removed. With sen-

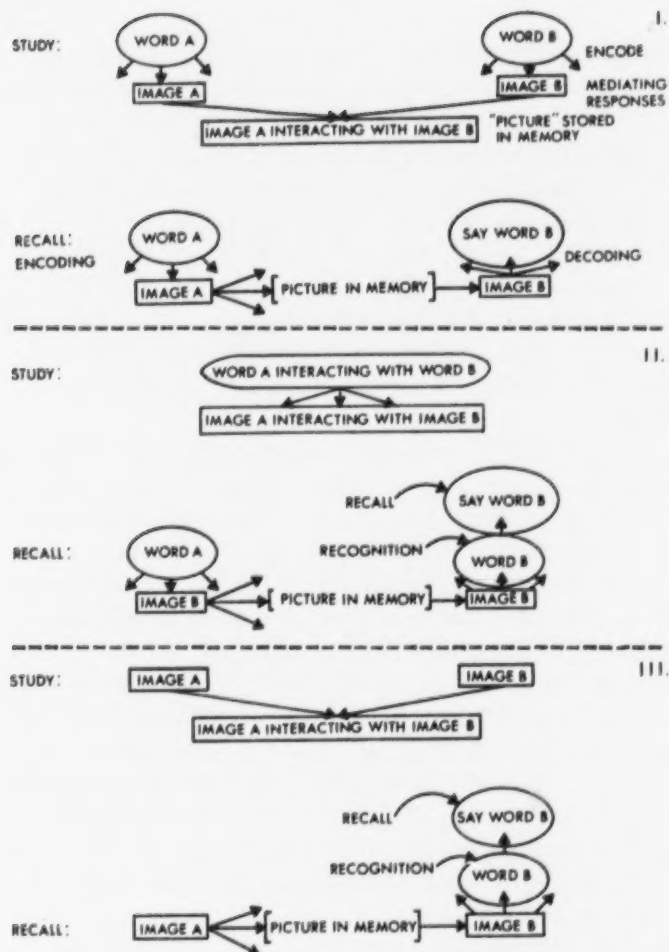


Fig. 5. Three diagrams representing the series of events taking place with imagery instructions for noun pairs (Panel I, taken from Bower, 1971), sentence-embedded noun pairs (Panel II), and picture pairs (Panel III).

tence-embedded pairs, the subject simply has to translate an imposed verbal interaction into a pictorial interaction. There is no need for him to generate an original interaction since it has already been supplied by the experimenter. With picture pairs, on the other hand, the transformation of verbal into pictorial stimuli is unnecessary, since separate images are already present. The subject may therefore skip this first step and simply generate an interacting image involving the two imposed pictures.

Thus, one transformation apiece has been eliminated when sentence-embedded and picture pairs constitute the to-be-interactively-imaged stimuli. If such transformations are moderately complex and/or require more processing time, then one would expect superior performance with these two types of materials, as compared to word pairs (especially with cognitively less mature subjects), even when comparable imagery instructions are given in all cases. Assuming that translating verbal interactions into imaginal interactions is of

similar complexity to translating unrelated pictures into interacting pictures, no performance differences between "imagery for sentences" and "imagery for pictures" would be predicted. However, when the recall phases of the two models are considered (see Panels II and III of Figure 5), an important difference is noted. With sentence-embedded paired associates, an additional transformation is required during recall: that of taking a word stimulus and recreating the pictorial representation of it. No such transformation is required for picture pairs, since the stimulus term is already in picture form. For this reason, one might expect a picture-over-sentence effect when imagery instructions are employed. Both of these should be larger than "imagery for words" as predicted from the comparative transformational operations involved in each.

Some data collected in conjunction with the study just described (Levin & Kaplan, in press) confirm the hypothesis. In addition to printed word pairs and paired pictures (line drawings), sentence-embedded word pairs were also constructed. Sixth grade subjects received one of the three types of materials under either regular or imagery instructions. The results of these manipulations are presented in Figure 6. In support of the hypothesis presented above, subjects given imagery instructions performed better when the materials were picture pairs than when they were sentence-embedded pairs. On the other hand,

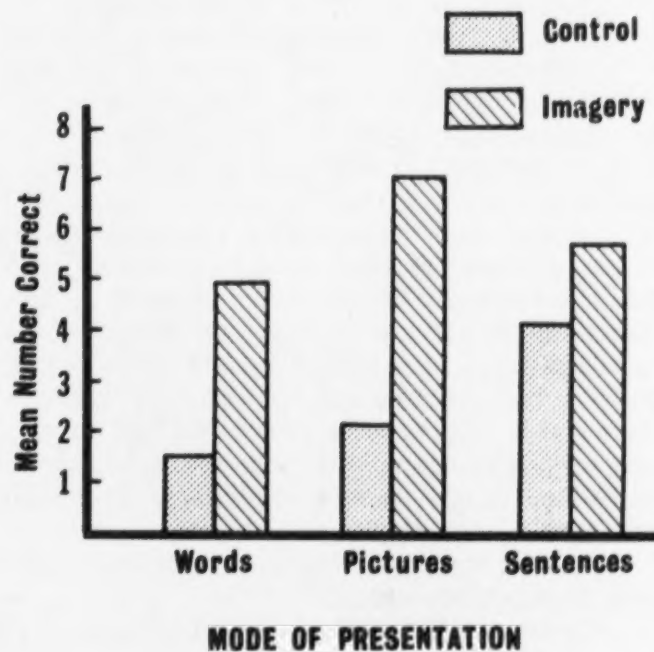


Fig. 6. Data from a study comparing imagery and regular instructions for object pairs presented as words, pictures, or words embedded in sentences.

subjects receiving regular instructions learned sentence-embedded pairs more easily than picture pairs. The latter result suggests that in the absence of imagery instructions, a sentence organization is more facilitative than a static pictorial representation, although the reverse may be true when more concrete representations (e.g., photographed real objects) are employed (Rohwer et al., 1967a).

The flow charts presented in Figure 5 also lend themselves to predictions regarding the effectiveness of imagery instructions under recognition and recall testing formats. Relatively larger differences between the two methods of testing for picture pairs would be expected than for word or sentence-embedded pairs, since in the former case the recognition cycle stops after the recall of the response picture (Panel III), whereas in the latter the response picture must be translated back into its correct verbal representation in order to recognize it (Panel II). One of our studies referred to earlier substantiates this. Second and fifth graders were given a mixed list of picture and word pairs under one of two types of instructions (regular or imagery) and under one of two testing methods (recall or recognition). The data relevant for this discussion are presented in Figure 7, where it may be seen that

for the cognitively less mature subjects (second graders) the imagery instructional effect was more potent when the task was picture recognition (an average of 84% correct with an imagery-control difference of 66%) than when it was picture recall (44% correct and a 34% difference). The corresponding figures for words are 58% and 44% with recognition, and 47% and 38% with recall.

Notice that there is very little improvement from second to fifth grade in the recognition "imagery for pictures" condition; the second graders are performing almost as well as the fifth graders. On the other hand, there is substantial second to fifth grade improvement in each of the other three imagery conditions. Of course, a ceiling effect is one explanation. At the same time, it may be noted that there is virtually no improvement from second to fifth grade in any of the control conditions, save recognition for pictures (precisely the opposite of what is seen in the imagery conditions). Finally, with regard to picture-word differences, although imagery facilitation for both types of material is of comparable magnitude in the fifth grade sample, the variability of scores in the "imagery for words" conditions is about five times greater than in the "imagery for pictures" conditions.

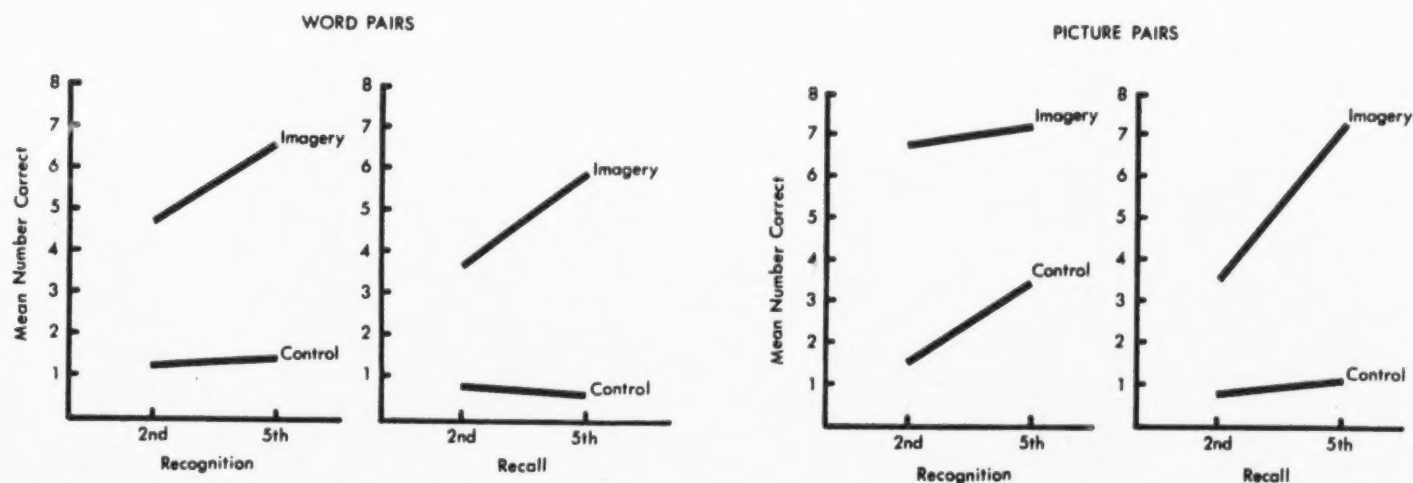


Fig. 7. Data from a study comparing imagery and regular instructions at two grade levels with two types of materials and two methods of testing.

Throughout this paper, only passing regard was paid to the initiating question. Along the way, such issues as picture-word differences, imagery vs. sentence effects and differing modes of cognitive representation have been briefly considered. Space has not permitted a discussion of individual differences (other than age differences) as they relate to these issues. The reader is referred elsewhere for investigations of mediational styles (Hohn &

Martin, 1970), mode preferences (Levin, Rohwer, & Cleary, 1971) and individual differences in imagery and verbal ability (Di Vesta, Ingersoll, & Sunshine, 1971). Hopefully, as more empirical and theoretical inputs serve to create less uncertainty concerning the interrelationships among cognitive processes and their development, we will indeed be able to indicate when a picture is worth a thousand words.

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II Action and Imagery in Children¹

Peter Wolff

The research I am going to report, carried out in collaboration with Joel Levin, is, quite frankly, not about learning, or even about memory. Instead, we have taken advantage of the facilitative effect of interactive imagery on paired-associate performance in order to investigate the imagery process itself and its development with age. In particular, based on some ideas of Piaget (Piaget, 1962; Piaget & Inhelder, 1967) and several Soviet psychologists (Anokhin, 1969; Beritoff, 1965), we were concerned with the possibly close mutual dependence between imagery production and the motor activity of the child.

Motor Activity and Perception

Several lines of investigation are leading to the conclusion that motoric processes are important in perception and perceptual development. Held and his co-workers, for example, using adaptation to distorting prisms as a model of perceptual development, found that voluntary activity, with resulting reafference or feedback, is necessary for perceptual adaptation to take place (Held & Hein, 1967).

Festinger and his colleagues, also using prismatic adaptation, have shown that the apparent curvature of a line is related not only to its projection on the retina, but also to the nature of the motoric response, either of the

eye or the hand, which is made to the stimulus (Festinger, Ono, Burnham, & Bamber, 1967).

Working directly with children, Zinchenko (in Zaporozhets, 1965) reported that recognition ability for nonsense forms increases from ages three to seven at the same time as the child's ocular or tactual scanning of the forms becomes more closely correlated with their perimeters. After approximately eight years of age, the amount of stimulus-correlated scanning necessary for correct recognition decreases, until finally the subject can process the stimulus "at a glance."

Wolff (1969) examined the immediate recognition of nonsense forms by children four to seven years of age. Subjects examined the forms visually, but were also allowed free manual contact with the forms. Voluntary tracing of the forms was common, and recognition accuracy was directly related to the amount of tracing generated by the child.

This and other research suggest that, especially in the young child, overt motor output may be central to the perceptual process.

Activity and Imagery

Piaget (Piaget, 1962; Piaget & Inhelder, 1967) hypothesized that, like perception, imagery formation has its basis in the motor imitative activity of the child. To represent an unseen object, the child must be able to recreate the motor components that constructed the original percept. Quoting Piaget,

...considered from the point of view of its origin, the image is a product of imitation. It is, in fact, an internalized imitation, one that can be made without resort to external gestures, though it is

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at first associated with such gestures.
...[1967, p. 40]

With tactual input alone, the child between three and four years of age can represent familiar objects by a static mental image (Page, 1959; Piaget & Inhelder, 1967). However, the formation of dynamic mental images, involving transformations of the objects themselves or systematic changes in their spatial position, does not occur until approximately seven years of age, or at the end of the pre-operational period. This delay in the appearance of dynamic mental imagery occurs because, in Piaget's view, the production of a dynamic image involves the use of rudimentary mental operations similar to those which later govern classificatory behavior, conservation, and logical thought. These operations, while reversible, are not structured into the closed systems which characterize thinking at the stages of concrete or formal operations.

In the experiments summarized below we are attempting to clarify this relationship between overt activity and imagery production in the young child. In addition, because of the paradigms used in the studies, the relationship between activity and learning is being investigated.

Experiments

Abundant evidence now exists that the presentation of a pictorial image relating the members of a paired-associate unit remarkably facilitates a subject's ability to later recombine the pair members (e.g., Reese, 1970). Similarly, if a subject, when presented with a pair of physically separate and unrelated pictures, is capable of producing such an image mentally, his performance is also facilitated (Bower, 1971; Bugelski, Kidd, & Segmen, 1968).

The purpose of the first experiment was to identify more precisely the age range over which the child's ability to form these dynamic images undergoes its most accelerated development. It was reasoned that children who cannot generate these images should show no facilitation on a paired-associate task from imagery instructions, relative to a group that receives no imagery instructions. At the opposite extreme, children with well-developed imaging processes should demonstrate the same degree of facilitation from imagery instruction as from an imposed interacting image.

The effects of two types of imposed images were investigated: those produced by the ex-

perimenter, and those generated by the subject himself. Experimenter-produced images were used to provide continuity with past research which has demonstrated the facilitative effect of imposed images on paired-associate learning. In the subject-produced imagery condition, subjects generated their own interacting imagery by manipulating the pairs, which in these studies were three-dimensional objects rather than pictures. We feel that this condition actually provides a more meaningful comparison with the imagery instruction condition, which also requires active, although covert, imagery production by the subject. This condition also allows direct observation of the child's ability to generate interactive visual imagery.

Thus there were four conditions: a Control group, which was instructed merely to remember that each pair of objects "go together"; an Imagery group, which was told to form a mental image of the members of each pair "playing together in some way"; an E-Manipulate group which observed the experimenter making each pair interact in a predetermined manner; and an S-Manipulate group, which generated their own interactions for each pair.

The objects to be paired were common children's toys; e.g., a metal airplane, a stuffed felt giraffe, a toy wristwatch, a plastic bear, a wooden block, a plastic truck, etc. They varied in size from 1 to 6 inches on the widest dimension. In the conditions in which imagery was generated by the experimenter, typical interactions were wrapping the watch around the giraffe's neck or placing the bear in the truck and moving them around the table. Subject-produced interactions turned out to be very similar, in most cases, to those generated by the experimenter.

Each of the 16 object pairs was presented once, followed by a recognition testing procedure in which the subject had to pair each stimulus object with its corresponding response object. Two age groups were tested, five and a half and eight and a half years, bracketing the age of transition from the preoperational to the concrete operational period.

Subjects were given practice trials illustrating both the presentation and testing phases of the procedure. For subjects in the Imagery and S-Manipulate conditions, possible interactions between the members of the practice pairs were demonstrated.

The results of this experiment were clear-cut. Performance in the Imagery condition improved markedly from kindergarten to third grade; the two imposed image conditions improved slightly; and the Control condition

showed no improvement. Pairwise comparisons with each group revealed that at kindergarten age, approximately five and a half years, the Control and Imagery conditions did not differ significantly, and both were significantly worse than each of the imposed image conditions.

At the third grade, however, the Imagery condition was statistically equivalent to both of the imposed image conditions, while all three were superior to the Control condition.

Inferring from these paired-associate performance data, Piaget's claim that the child's ability to generate dynamic mental imagery develops at about age seven is remarkably accurate.

In this experiment, children in the S-Manipulate condition who generated their own imposed imagery not only performed a motor "gesture," or activity, which related the pairs—they also observed visually the resulting interacting image. In the next experiment we began to explore more directly the relationship between imagery and overt activity. If, as Piaget suggests, imagery production depends at first on overt representational activity, then a pre-imagery child should demonstrate paired-associate facilitation in the S-Manipulate condition, even if he does not see the resulting interaction or his manipulations. To provide a way in which the subjects could manipulate the toys without concurrent visual input, a "house" was constructed from a cardboard box. The front of the box was replaced with a cloth curtain and the back of the box was removed so that the experimenter could observe the child's actions.

Subjects in an Imagery condition were told to take the toys, one in each hand, through the curtain into the house and imagine the toys playing together. They were not permitted to move their hands once the toys were inside the house. Subjects in an "invisible" Manipulate condition were told to take the toys into the house and make them play together, while trying to make up a picture in their minds of whatever the toys were doing.

Because we removed the very small toys and those which had sharp edges, the list length was reduced to 12 pairs. Otherwise, the presentation and test procedures were the same as in the first experiment. In order to increase the sample size, kindergartners and first graders served as subjects.

Invisible manipulation resulted in higher paired-associate performance than imagery instruction, statistically a highly significant finding. In the first experiment, in which subjects in the S-Manipulate condition had

visual access to the object pairs which they were manipulating, performance of the kindergarten sample in the S-Manipulate condition was 54% higher than that in the Imagery condition. In this experiment, which excluded visual cues, the amount of facilitation was almost identical—58% for the kindergarten sample and 61% for the first grade.

The motor activity involved in manipulation of the object pairs apparently allowed the formation of dynamic images by children who were otherwise unable to form them. The attitude of subjects in the Manipulate condition — head motionless, eyes turned "inward" — suggested that they were actually experiencing mental images of their activity. The children's subjective reports support this conclusion. Almost all children in the Manipulate condition reported imaginary visual experiences of the objects interacting, while many children in the Imagery condition claimed that they could not form such an image. Interestingly, some of these subjects could experience each of the objects of a pair playing separately in a non-specific manner, but could not experience an interaction between them.

If the motorically-produced interactions are basic to the production of imagery, and to the facilitative effects found in the recognition task, it might be expected that subject-generated interactions would be more effective than experimenter-generated interactions. In the first experiment, exactly the opposite was found—experimenter-produced interactions resulted in higher recognition performance, although the difference was only marginally significant by post hoc test. This finding is fairly inconclusive since the children could not always form effective interactions for all of the pairs, whereas the experimenter's interactions were clear and well-formed. We therefore examined the performer-observer distinction in a separate study in which kindergarten children were tested in pairs. One child generated the interactions while another child watched, establishing some degree of control over the quality of the interactions available to the observers. Performers re-paired a significantly greater number of items than observers, although the difference was only 1.6 items. The difference was smaller on an immediate than on a 24-hour test, .7 versus 2.2 items, although the interaction with delay was not significant. Interestingly, most of the performer-observer difference was accounted for by male subjects. An extremely tentative conclusion from this result is that different encoding processes may be used by the two sexes.

In another experiment, we attempted to answer several additional questions about the phenomenon of activity-mediated imagery. First, what would happen to paired-associate performance under Imagery and Manipulate instructions as visual and tactual contacts with the to-be-paired objects are eliminated? Second, does the absence of visual and/or tactual contact with the pair members affect the quality of the child's manipulation of these objects? And third, is the quality of this manipulation related to the child's ability to later re-pair the objects?

Eight conditions were examined by comparing Manipulate with Imagery instructions under four combinations of visual and tactual contact. In a Tactual-Visual condition, subjects held each pair of toys, one in each hand, and either caused the toys to interact or attempted to form images relating the pairs. In a Tactual-No Visual condition, the same procedure was followed except that the appropriate instructions were executed out of sight, inside the "house" used in the second experiment. These four conditions served as a replication of the Imagery and Manipulate conditions of the first two experiments, but with a common list, making comparisons of absolute performance levels possible.

In the third condition, subjects had visual, but no tactual, contact with the pairs (Visual-No Tactual). The toys were placed side by side on the table, and subjects either pantomimed an interaction, as if the toys were in their hands, or else attempted to form an interacting image.

Finally, in the fourth condition, subjects had neither tactual nor visual contact with the toys (No Visual-No Tactual). They examined the toys briefly, and then carried them into the house. As soon as the toys were under the box, they were taken from the subject, who then attempted to produce either a pantomime interaction or an interacting image for the pair.

For each subject in the four Manipulate conditions, a rating from zero to 3 was given to characterize the quality of the child's manipulation. A zero rating indicated rudimentary and stereotyped interactions with almost no variability of activity among the pairs. At the other extreme, a rating of 3 signified unique and detailed interactions for at least 10 out of 12 of the pairs. Ratings of 1 or 2 indicated intermediate levels of manipulation. These ratings were made before the recognition phase of the procedure was begun.

Briefly summarizing the results, the findings of the first two experiments were repli-

cated—when the child had tactual contact with the toys, manipulation facilitated paired-associate performance relative to imagery instructions whether or not the pairs were visible. Again the percentage facilitation was almost the same when visual contact was absent as it was when present—100% and 108%, respectively, and highly significant in each case. When tactual contact was absent, however, pantomimed manipulation did not significantly facilitate performance relative to imagery instructions.

Summing over Imagery and Manipulate conditions, the number of available cues affected recognition performance. Visual and tactual contact resulted in more correct responses than either visual or tactual contact alone, which in turn resulted in a greater number of correct responses than the condition in which neither visual nor tactual cues were available.

In order to test the relative importance of tactual and visual contact for performance in the Manipulate and Imagery conditions, the Visual-No Tactual condition was compared with the No Visual-Tactual condition. Tactual contact was relatively more important for activity-mediated facilitation, while visual contact was more important when the child was required to construct a mental image without activity.

Analysis of the ratings of quality of activity produced in the four Manipulate conditions showed that the presence or absence of tactual contact was the only important factor in determining the quality of manipulation. When the child was not actually holding the toys, his ability to form imaginary interactions was impaired. Finally, the average correlation between manipulation ratings and paired-associate performance in these four conditions was .325, which, while low, is significant.

Discussion

The results of this research are strongly consistent with the view that the child's ability to generate dynamic imagery is rooted in his motor activity. While the five- to six-year-old must produce this activity overtly, after approximately eight and a half years, this activity is no longer necessary for the generation of imagery.

These findings are remarkably parallel to those of the developmental perceptual research reviewed above, in which the dependence of the perceptual response on overt activity decreases with age (Wolff, 1969; Zinchenko, in Zaporozhets, 1965). Age com-

parisons between the two processes must be made with caution because of the different tasks used in the two areas of research. Tentatively, however, it appears that both perception and imagery become independent of overt activity at approximately the same age—between six and seven years. How to best characterize these processes once they "go underground" is a serious problem in both areas of investigation.

Festinger et al. (1967) have used the concept of "efferent [or motor] readiness" to explain the occurrence of perception without activity. Similarly, Piaget and Inhelder (1967) have explained the production of imagery in the older child by positing that the overt gesture becomes "internalized." These constructs are, of course, extremely vague, and hopefully will be clarified in future research and theory.

The focus of this discussion so far has been on the importance of activity in the formation of dynamic imagery. However, several authors have hypothesized that the reverse is also true—imagery plays an essential role in the planning and guidance of ongoing activity. Miller, Galanter, and Pribram (1960) have discussed the importance of the visual image as a plan for future behavior. Greenwald (1970) has recently resurrected William James's (1890) "ideo-motor theory," which claims that voluntary activity is always preceded by an image of its consequences.

This reciprocal relationship between imagery and activity has been most heavily emphasized in the Soviet Union. During ongoing behavior, an "orienting image" is formed either through overt ocular or haptic activity, or else covertly. This orienting image in turn serves as a program for the ongoing behavior. Anokhin (1969) has proposed that this orienting image, which he calls the "acceptor of affect," not only programs the activity, but also serves as the referent stimulation against which the actual activity is continually compared. Any

discrepancy between programmed and actual activity is continuously corrected.

Bruner, Olver, and Greenfield (1966) have proposed that as a result of the exercise of a particular response, an atemporal representation, or image, of that response develops. "This primitive representation or trace guides a new response and makes some kind of representation possible. It thus 'frees' behavior from complete peripheral control" (p. 18).

The results of our experiments raise some interesting questions with respect to this cybernetic model of behavior. The younger children in the Manipulate conditions generated highly specific and appropriate interactions between the members of the object pairs as long as they had tactual contact with the toys. Furthermore, somewhat to our surprise, the quality of manipulation was just as high when these subjects were operating "blind" as when they could see the consequences of their actions with the toys. Yet, inferring from the recognition data, these young children were able to form a dynamic image of the object pairs interacting only when they were concurrently engaged in the relevant activity.

If we can assume that the images formed without activity by the older children are indeed playing the functional role hypothesized by these theorists, and if in turn these anticipatory images are functionally equivalent to the images formed by the younger children during active manipulation of the objects, then it becomes impossible to speak of a delay in real time between the planning of the behavior and its execution, particularly in the case of the pre-imagery children. These two functions, planning and execution, are both mutually dependent and simultaneously emerging in ongoing behavior. As the child develops, the planning function can temporally precede the execution of the activity. It may be that this planning function, or intention, dissociated from its motor execution, is what is experienced as dynamic mental imagery.

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III Interference Among Images?¹

Robert E. Davidson

I have entitled this paper "Interference Among Images?" I could have entitled it "A Search for the Independent Image." However, our chairman, Joel Levin, because he knows of my interest in language and in particular semantics, offers a title which I prefer above all. His suggested title is "Imagery as It Unrelates to Language."

That title is, I think, a succinct statement of what I am about. That is to say, if we are to deal with the topic of imagery at all, then we should be able to entertain the idea that imagery might exist independent of any other representational or symbolic system. In my particular case, I would like to know if a visual image can exist independent of language. The use of the word "interference" in the title of this paper does serve a purpose, however. It refers to the method I used in my search for the independent image; the method of transfer. Postman (1970) suggests that questions of what has been learned (or properties of storage) can be clarified by tests of transfer.

Interference effects in behavior are pervasive phenomena. Interference occurs in everyday experience as well as in the psychological laboratory. In the former case, for example, United States citizens traveling in Britain experience not a little confusion and apprehension when forced to drive on the "wrong" side of the road. That is bad enough, but interference effects can cost lives. Underwood (1966), for example, notes that an airplane accident was traceable to a pilot who, because of similarities

in the cockpit configuration of two planes, inadvertently actuated the landing gear switch instead of the flaps.

Only slightly less dramatic are the interference effects that arise in the verbal learning laboratory. I hope that you will be able to bear the disappointment if I do not detail the history of the experimental study of transfer using verbal materials. However, I will assume that you have some knowledge of that tradition when I turn to the experimental studies. The reason I need to assume your knowledge of such matters is that the studies make use of the typical (and in some cases the not so typical) transfer paradigms of verbal learning.

That is to say, it is within the framework of the transfer experiment that I have asked the question, "Is there interference among images?" In particular, I ask the question in terms of visual images or mental pictures with or without other associated sensory or motor components.

I will want to return to the subject of transfer, but first let me provide some information that hints at my orientation to the study of imagery and learning.

The Theoretical Orientation

A number of assumptions have guided this research program. Let me quickly outline just a few of these.

First, I do make the assumption that a visual image (a mental picture) can exist as an independent representation of the world. Imagery may, but need not, be interconnected with any other representational system. That is, a visual percept (qua percept) subsequently may be represented in the mind as a mental picture without any connections to any other symbolic system—e.g., enactive or semantic.

An unconnected visual image is, in effect,

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stripped of all meaning. A mental picture of this kind corresponds, I think, to what Paivio (1970a) has called an image that has representational meaning. Paivio suggests that familiarity ratings or frequency counts for names of visually perceptible objects are appropriate correlates to representational imagery. My own assumption about this kind of image is, perhaps, more austere or barren. An absolutely unfamiliar word standing for an object—for example, the word "nargileh"—cannot trigger a mental picture of the object. Yet, if I present a picture of such an object, then that picture could serve subsequently as a representational image. Although even in this case I would have to assume that the picture of the nargileh is itself stripped of meaning. With the active mind of the adult, that assumption is probably wrong. That is, the mature subject would, at the very least, liken the object to something that is familiar to him and thus make it a "meaningful" object in some sense. The subject may attribute meaning to the object, no matter how inappropriate, by creating analogies to already existing schemata for form or function. Before you look at the picture of a nargileh, can you picture it in your mind? Probably not, unless you are familiar with objects of the Eastern world. But when you do look at the picture, you, as adults, will recognize it as the ever familiar "hookah" (Figure 8).



Fig. 8. A nargileh.

Now that you have seen the nargileh and its obvious functional use—i.e., you have rendered it meaningful in some symbolic sense—the picture of the object, indeed the word symbol for the object, takes on more than represen-

tational meaning. A visual image of the object is now more than a representational image.

That brings me to another assumption, viz.—when a visual image is functional in behavior, it is always tied to some other symbolic system. The most likely candidate for that other symbolic system is the semantic component of language. Thus, when imagery is said to facilitate learning in a paired-associate task, or when imagery is said to aid comprehension of sentences, then we are focusing on just one element in an interrelated system. It is the interrelated system that provides the facilitation or comprehension and not imagery per se. Functional imagery is assumed to be inexorably woven into the fabric of language.

Let me be very clear about this assumed connection between functional imagery and language. A functional image for an object or event may be triggered in the mind, and that image may be devoid of any intraverbal accompaniment. That is, labels for objects or internalized (i.e., covert but "conscious") verbal descriptions of interactive events need not occur for a mental picture to be functional in mediating behavior. Let me repeat, overt or covert verbalization need not occur.² The point that I want to make is that while I assume that functional imagery can be non-verbal, I do not assume that imagery is not non-language.

What I am suggesting here is a neo-Chomskian view which says that semantics or meaning should be interpreted in terms of the deep structures of language. Going further, I would suggest that a visual image may be one kind of surface structure transformation from deep structure—a transformation that is not essentially different from an internally verbalized surface structure—e.g., a short active affirmative declarative sentence.³ An appro-

²There is a good deal of evidence (Rohwer, 1970) to suggest that internal and external verbal accompaniment provides additional increments to performance over that provided by imagery alone.

³I think it is true that a visual image is a spatially organized surface structure, while a covert or overt verbalization is a sequentially organized surface structure (Paivio, 1970). In fact, one might develop the interesting argument that a visual image, because it is a parallel process or spatially organized structure, might be "closer to" deep structure than the sentence is. That is, the deep structures of language may themselves be organized in a parallel processing system—as any interpreter of double entendre, poetry, or Alice in Wonderland might suspect.

priate computer programming analogy is this: functional visual imagery is one kind of GO TO statement of a semantic subroutine within a language program. Sentence production is a different GO TO statement.

Thus, I can think the sentence "King Kong crushes the Volkswagen," or I can create an image of such a fanciful event without any internalized verbal accompaniment, or I can do both. The essential point is that both the image and the internal (but conscious) verbalization are generated from one abstract deep structure.

If we look at the matter in terms of stimulus input to a subject, I might utter the King Kong sentence or I might compose a pictorial representation of the event. Again in both cases, I assume that a single abstract deep structure is triggered which provides meaning for both the sentence and the interactive picture.

The Transfer Methodology

Transfer studies in the verbal learning tradition ask the subject to learn successive lists. The items in the first list are designated as A-B. The As are stimuli and the Bs are responses. After learning the first list to some criterion, the subjects are transferred to a second list. Designations for the second list vary depending on the study. Thus we might designate the second list items as A-C (stimuli the same as first list), C-B (responses the same), C-D (stimuli and responses different from first list), etc. Now, specific transfer effects in verbal learning may be positive or negative depending on the relationships that exist between the stimulus and response terms in successive lists. Thus, it is known that negative transfer occurs in the A-B, A-C paradigm where new responses are paired with old stimuli. To evaluate the specific transfer effects, comparisons are made to a reference or control paradigm A-B, C-D where successive lists are made up of unrelated stimuli and unrelated responses.⁴

In addition to the fact that words and pictures have been used as stimuli in our experiments, two fundamental features characterize

⁴The designations for the transfer situations of A-B, A-C; A-B, C-D; etc. are carry-overs from an earlier period in verbal learning. In actual fact, current studies in transfer turn these lists around. All Ss learn the same second list (A-B), and the specific manipulations are carried out during first list learning (A-C, C-D, etc.). See Underwood (1966).

the learning materials. First, the stimulus and response items are often embedded in sentences. For example, the stimulus-response pair "bat-horse" (whether presented as printed words or pictured objects) could serve as the subject and direct object in the sentence, "The baseball bat hit the horse."

Second, the word or picture stimuli have multiple meanings; words like bat, or tie, or solution, or spirits, etc. Thus, two different meanings for the word "bat" could be signaled by a picture depicting a flying mammal or a picture of a baseball bat. Or, if the word "bat" were written, it could be modified in a way that would signal the meaning intended, e.g., "baseball bat."

Now, with the transfer situation in mind, notice that the A-B, A-C paradigm could be represented by the following sentence frames: "The baseball bat hit the girl" (first list), and "The baseball bat hit the horse" (second list). The meaning of "bat" remains constant over lists. However, with appropriate modifiers, the meaning of "bat" can change over lists. Thus, a semantic change on the stimulus term could generate the following sentences: "The winged bat bit the girl" (first list), and "The baseball bat hit the horse" (second list). In this case, a different kind of paradigm results. We have termed this paradigm A-B, A^s-C, where the superscript *s* refers to the semantic change.

What kind of transfer results could we expect in A^s-C? Well, it was our hypothesis that this paradigm should behave like a C-D control. That is, while the stimulus terms of the first and second list are orthographically identical, their conceptual or semantic character has been changed, and the change of meaning should act in a way that makes the sentences of the two lists unrelated.

The above argument is, essentially, one that is grounded in current semantic theory (cf., Katz & Fodor, 1963; Miller, 1967; Minsky, 1968). The assumption is that the meaning of a word consists of a set or bundle of semantic features. There are at least two different or non-overlapping sets of semantic features for the ambiguous stimulus words in A^s-C (e.g., bat); therefore the meanings of the sentences that use the ambiguous words should be represented differently in deep structure.

There are other grounds for suggesting that the successive lists of A^s-C are unrelated. Let me mention just a few of these other viewpoints without elaborating them to any great extent.

Consider the cognitive process of imagery. Here we have the strongest case for believing that the successive lists of sentences in A^s-C

are unrelated. If the sentences are transformed into interactive images, a transformation that makes the visual images independent of language, then clearly, the image of bat-biting-girl is different from the image of bat-hitting-horse.⁵

Another viewpoint from cognitive psychology (Bower, 1970) is not unlike the semantic marker and imagery positions already noted; although Bower's stress is not so much on the materials as it is on the information processing capabilities of the human learner. Bower's "perceptual interpreter" very likely would interpret the sentences in A^S-C appropriately; would "cognitively emphasize" the appropriate features of the words and sentences, and would not, therefore, confuse the sentences over lists. Again, the prediction is that A^S-C should yield transfer results like those of C-D.

There is an interesting parallel to Bower's perceptual interpreter in some of the current writings from verbal learning. Cramer (1969) and Postman and Stark (1969) have commented on the difficulty of establishing the phenomenon of mediated interference in transfer situations where there is some kind of associative connection between the stimulus terms in successive paired-associate lists. The authors are not at all loath to attribute to their subjects the ability to "turn off" associative connections under conditions of interference. That is, subjects might be expected to utilize associative connections when they facilitate acquisition of a transfer task, but not when they become a source of interference.

Just as interesting a viewpoint as any mentioned so far is that of Martin (1968). Martin's theory of paired-associate transfer involves what he calls the encoding variability hypothesis. The hypothesis states that "analyzable nominal stimuli are variably encodable and hence may be perceived differently on different occasions." Martin was addressing himself to the role of stimulus meaningfulness (M) in a variety of verbal learning situations. In a paired-associate, negative transfer situation, for example, low-M stimuli are "fraction-

able"; therefore they offer the possibility of being recoded during second list learning. As a result, negative transfer for low-M stimuli is reduced. High-M stimuli, on the other hand, are amenable to recoding, and typical negative transfer occurs during second list learning. Although the encoding variability hypothesis was not advanced with multiple-meaning words in mind, it is obviously applicable to such stimuli (cf., Bower, 1970; Shepard, 1963).

Martin's overall formulation has wide generality over many seemingly disparate phenomena. These include certain findings in short-term memory (Murdock, 1961), list differentiation (Gibson, 1940), the "interference paradox" (Underwood & Schulz, 1960), and picture vs. word differences in paired-associate learning (Wicker, 1970).

Martin's formulation also generalizes to the studies to be reported here. In essence, the assumption is made that multiple-meaning words are fractionable in the very same sense that low-M stimuli are fractionable. That the stimulus terms are fractionable allows the experimenter to picture them or embed them in sentences in a way that recodes the terms. It should also be the case, therefore, that the subject can "hook up" the new responses in second list learning to the recoded stimulus terms without suffering any negative transfer. Once again, the prediction would be that A^S-C should function like C-D. Thus, there are many theoretical bases to support the hypothesis that successive lists of sentences in the A^S-C paradigm are unrelated. The following experiments bear on that hypothesis.

Experiments

Elizabeth Schwenn Ghatala, Jan Adams, and I (Davidson, Schwenn & Adams, 1970) carried out an experiment which manipulated the transfer paradigms shown in Table 2.

In this study, the traditional paradigms of A-B, A-C (A-C) and A-B, C-D (C-D) were used to evaluate the specific transfer effects of a third paradigm, A-B, A^S-C (A^S-C), where the orthographically identical stimulus terms were altered semantically by selecting appropriate modifiers. Notice that the meaning of "ball" is changed over lists in the sentence (S) condition. To reiterate, our thinking behind this experiment was this: while the stimulus terms of the first and second list are orthographically identical, their semantic character has been changed, they can be encoded differently, and presumably a new encoding should make the A^S-C paradigm function like C-D. As I suggested earlier, that prediction is even

⁵Presumably these are the images that are evoked despite the fact that the sentence signals past tense. Verb tense presents an interesting problem for imagery. It may be, as Arthur Taylor has suggested (personal communication), that imagery for paired-associate learning is most effective, and perhaps only possible, when the items are rendered in a present tense interaction.

Table 2
Materials for Five Experimental Paradigms
(Examples from Davidson, Schwenn, & Adams, 1970)

Paradigm	List 1	List 2
A-C/S	The hard <u>ball</u> hurt the <u>girl</u> .	The hard <u>ball</u> hit the <u>fence</u> .
A ^S -C/S	The fireman's <u>ball</u> pleased the <u>girl</u> .	The hard <u>ball</u> hit the <u>fence</u> .
C-D/S	The hickory <u>stick</u> hurt the <u>girl</u> .	The hard <u>ball</u> hit the <u>fence</u> .
A-C/PA	<u>ball</u> <u>girl</u>	<u>ball</u> <u>fence</u>
C-D/PA	<u>stick</u> <u>girl</u>	<u>ball</u> <u>fence</u>

more tenable when we entertain the notion that the A^S-C sentences might, in Paivio's (1970a) terms, "flip over into a non-verbal code." That is, if the sentences in both lists are transformed into mental images, then they should, indeed, function like sentences in a C-D control.

Subjects in this experiment were sixth grade children. Sixteen Ss were assigned to each of the five conditions.

The learning materials consisted of lists of 12 pairs of nouns with frequencies from 2 to AA (Thorndike & Lorge, 1944). All lists shared equally words of the varying frequencies. This was true with respect to both the stimulus and response pairs and the sentence contexts in which they were embedded. The to-be-learned pairs were typed in lower case and underlined. The sentence contexts were all simple past-tense declaratives with the paired nouns functioning as subject and direct object. The initial article was capitalized and the sentence ended with a period. Five random orders of the lists were prepared. All groups learned the same second list (see footnote 4).

The learning materials were presented on an MTA-100 Scholar using the study-test method. The rate was 4.5 sec. for both the study and test portions of each trial, with a 4.5-sec. intertrial interval. First list learning criterion was 11/12, and the second list was presented for five study-test trials. Sentence contexts were removed during the test portion of each trial.

The transfer results are shown in Figure 9. Analyses indicated negative transfer in A-C/PA (paired associate) relative to C-D/PA. This is a typical finding in transfer studies. On the other hand, there was no difference between the A-C and C-D paradigms when they were placed in sentence contexts. Sentences act to reduce negative transfer. Of particular interest for our purposes here was the finding

interest for our purposes here was the finding that A^S-C produced a great deal of negative transfer early in list 2 learning. This result, relative to the A-C sentence group, is quite important. It suggested to us that the subjects were momentarily confused because of the identical verbalized labels of the stimulus terms. Yet, if the matter rested simply on the fact that verbalizable name tags were the

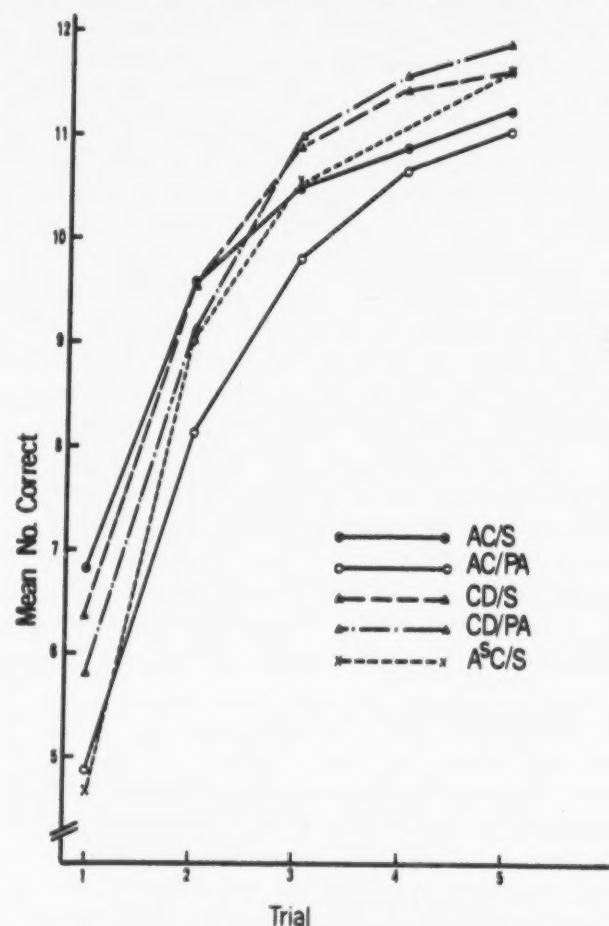


Fig. 9. Acquisition curves for five experimental conditions in List 2 learning (data from Davidson, Schwenn, & Adams, 1970).

same over lists, then the A-C sentence condition should suffer as well. It didn't. On the other hand, if we were to suggest that it was, in fact, the change of meaning (or a change of image?) that produced the effect, then we were back to the original argument; A^S-C should function like the reference paradigm C-D. Again, it didn't. We were faced with a puzzle, and we found ourselves going in circles in our attempt to interpret the data. Thus it was with a sense of relief that we turned our attention to one facet of this study. Luckily, it was an aspect that we thought might help us with a solution to the puzzle. What we began to pay attention to was the fact that new transfer paradigms can be created when the multiple-meaning, paired-associate items are embedded in sentences. The A^S-C paradigm is one of the more obvious constructions. The next transfer study exploits that capability to a greater extent. Before I outline that study, however, let me provide some of the background for it.

Functional imagery is closely tied to concreteness. It is relatively easy to create an image for "concrete" words. Imagery for "abstract" words, on the other hand, is very difficult, at least for most people. It is true that E. B. Titchener reported that his visual image for the word "meaning" was "the blue-gray tip of a kind of scoop which has a bit of yellow about it (probably a part of the handle) and which is just digging into a dark mass of what appears to be plastic material" (Brown, 1958). I am not sure just what is to be made of an introspective report such as that. But, however that may be, subjects are quite willing to give imagery ratings for words varying on some semantically intuitive abstractness-concreteness dimension (Paivio, Yuille, & Madigan, 1968). Not surprisingly, the imagery (I) values calculated from the subjects' ratings are consonant with semantic intuition. "Abstract" words yield small I values and "concrete" words yield large I values. Furthermore, I value is related to ease of learning in a paired-associate task (Paivio, 1965). Thus, abstract-abstract, stimulus-response pairs are more difficult to learn than concrete-concrete pairs.

At this point, let me introduce a hypothetical histogram (Figure 10). Perhaps you will recognize the figure as an idealized version of some actual data reported by Paivio (1965). Pairs designated AA are abstract-stimulus, abstract-response pairs; AC items are abstract-stimulus, concrete-response pairs, etc.

Given this state of affairs, it should be possible to make a semantic change on the

stimulus (or response) term in at least two ways. First, it is possible to form abstract-abstract (AA) pairs or concrete-concrete (CC) pairs, etc., that remain AA or CC over lists. For example, the pair "coach-idea" is a CA item type. The word "coach" when embedded in the sentence, "The football coach had the idea," is concrete, and the item type is concrete-abstract (CA). The same word in the sentence, "The overland coach made up the time," is still concrete (and still a CA item), but the meaning has been changed. An item of this type, manipulated over transfer lists, is exactly like the A^S-C paradigm of the first experiment. However, it is possible to construct a different type of A^S-C paradigm (discussed below). Therefore, it becomes necessary to recode the A^S-C paradigm into two types. The A^S-C paradigm that keeps its status on either an abstract or concrete dimension across transfer lists is termed an A-B, A^{SW}-C (hereafter 'SW') paradigm, where the superscript w refers to a semantic change within the same dimension.

A second type of A^S-C paradigm is possible if two semantic changes are effected. That is, it is possible to change the semantic classification as well as the meaning of the stimulus term. Thus a "concrete" term might be rendered "abstract," and an "abstract" term might be rendered "concrete." Again, this is accomplished by signaling different meanings.

The word "solution" in the sentence, "An easy solution solved the game," is relatively abstract. But the same word in the sentence, "Chemical solution dissolved the paper," is more concrete. Presumably the I value for the phrase "easy solution" would be relatively

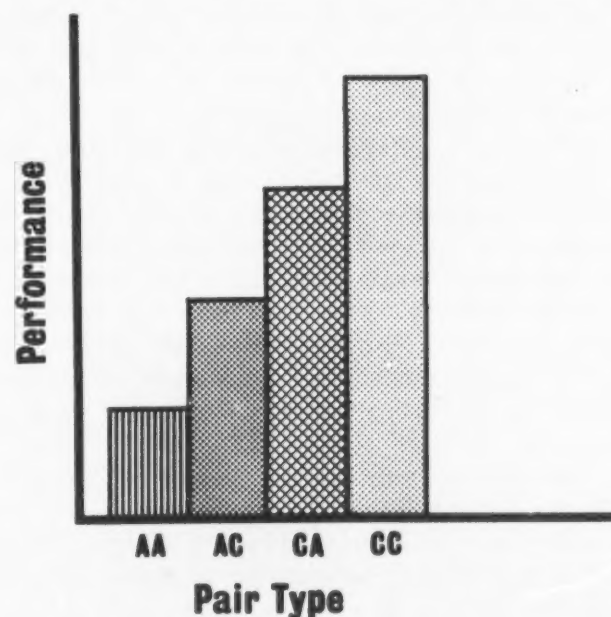


Fig. 10. Hypothetical figure depicting performance on four item types.

low, while the I value for the phrase "chemical solution" would be relatively high. If this is so, then the AC pair "(easy) solution-game" in first list learning would, in second list, become the CC pair "(chemical) solution-paper." Similarly, the CC pair "(earthquake) fault-bridge" in first list would, in the second list, become the AC pair "(personal) fault-officer." Stimulus members that change their meaning and change their classification on an abstractness-concreteness dimension define the A-B, A^{SO}-C (hereafter S^O) paradigm, where the superscript o refers to a semantic change outside the original dimension over lists.

As yet, there is no independent evidence that an S^O item does, in fact, change in I value. However, tangential evidence that such would be the case is provided by Davidson (1970, 1971) who asked subjects to rate metaphorical phrases and clichés (e.g., "golden opportunity") and by Philipchalk and Begg (1970) who showed that nonsense syllables modified by high or low I value words are easier to learn in a paired-associate task.

The following experiment, then, was predicated on the assumption that the semantic classification (i.e., abstract to concrete and concrete to abstract), as well as the meaning of the stimulus words, can be changed by using appropriate sentence contexts. A corollary assumption holds that the I value for a multiple-meaning word that changes its semantic classification is relatively higher or lower depending on the specific meaning that is signaled.

The relationship between the first and second list stimulus (A) terms in the SW paradigm is semantically different in only one way, while the relationship between the A terms in S^O is two ways different. Thus, S^O should have even a greater chance to function like C-D. Furthermore, because the four pair types in S^O change over lists, the recoded stimulus terms should serve not only to reduce negative transfer, but the subject's performance on each pair type should show a reordering that reflects the change in I value. Thus, the subject's performance on the AA and AC items in first list should show a relative increase in transfer because those items are recoded as CA and CC in second list.

Two independent groups of college subjects learned two 16-item mixed lists. Paradigms and item types were within-subject manipulations. One group (pairs) learned the paired associates without benefit of sentence contexts; therefore only the A-C and C-D paradigms were possible manipulations. The second group (sentence) learned the same

items in sentence contexts which allowed the manipulation of the four paradigms and the four item types.

The transfer results are shown in Figure 11. First, the results for the group that learned the pairs only show typical A-C negative transfer relative to C-D. Also, the ordering of item types in transfer, while not as perfect as the idealization shown in Figure 3, essentially is in agreement. The results for the sentence groups are more interesting. A test for paradigms was significant ($F = 4.12$, $df = 3/36$, $p < .02$). All of the transfer paradigms for specific effects showed negative transfer relative to C-D. In particular, the S^O paradigm, predicted to be most like C-D, showed the greatest amount of negative transfer. On the other hand, the effect for item type in transfer follows the prediction very well. In particular, notice the recoded stimulus terms in the S^O paradigm. The AA item in transfer (formerly a CA item in first list) is lowest followed by AC, CA, and CC in the predicted order. Presumably, the subject's performance reflects the change in I value for the stimulus terms.

Where does that leave us? On the one hand, there is overall negative transfer in the S^O paradigm. On the other hand, subjects seem to be responding appropriately to the semantic change or the imagery value of the recoded words. Is it possible that there really is no semantic or imagery interference? If that is the case, then what is the source of the specific negative transfer in the semantic change paradigms? We had some ideas about this, and the following experiment was designed to get at the source of negative transfer while demonstrating the validity of the fundamental hypothesis that A^S-C should function like C-D. We made a number of tactical changes in our experimental methods. The changes involved the stimulus materials, task demands, and subject populations. The first tactical change was to use pictures as stimulus materials. After all, it is a simple matter to picture the two meanings of ambiguous words, and, we thought, pictured representations of the two different meanings certainly should make the semantic change paradigm act like a control paradigm. That is, pictorial representation gives strong support to the subject to keep his meanings or images separate. As an example, see Figure 12.

The second change was to control items for their semantic frequency in the language. For example, the stimulus item "bat" has a semantic count of 23 per mille when referring to a baseball bat, but the same word has a

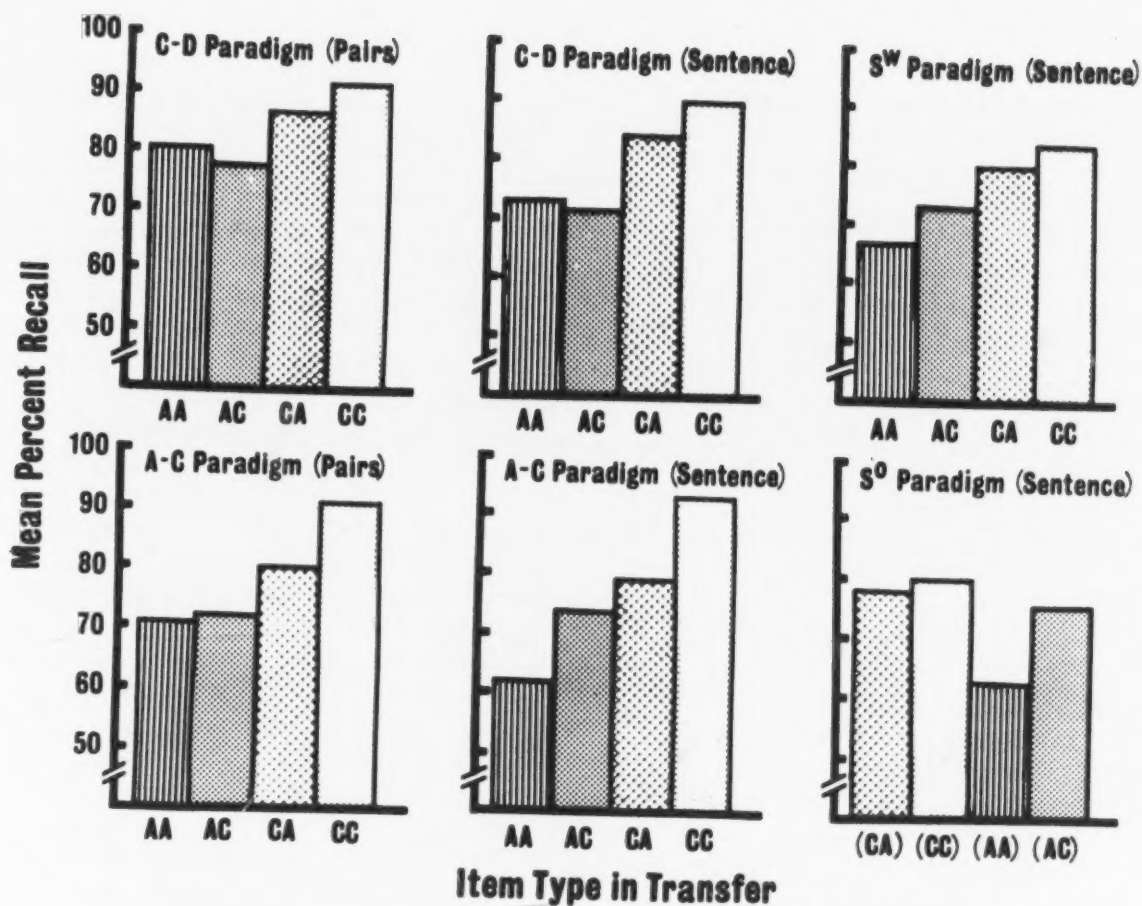


Fig. 11. Within-subject performance on paradigms and item types for two experimental groups (Pairs and Sentence).

count of only 5 per mille when referring to a winged mammal. The importance of using pictures and high and low semantic frequency items will become obvious when the variables are considered in connection with the change in task demands and subject populations. The change in task demands involved a switch from recall to a recognition mode of responding, and the populations sampled were kindergarten, second, and fourth grade children.

A recognition mode allows the subjects to point to their response from among all of the available responses. Davidson and Adams (1970) suggested that the advantage of such a procedure is to mitigate the effects of an image decoding problem. Paivio (1970b) asserted, "Young children have greater difficulty than adults in making the symbolic transformation from mediating image to the required verbal response."

At the same time, Rohwer (1970) suggested that imagery storage, and presumably imagery utilization, "is amplified when complementary verbal representation is stored simultaneously with the visual" (see footnote 2). If Rohwer

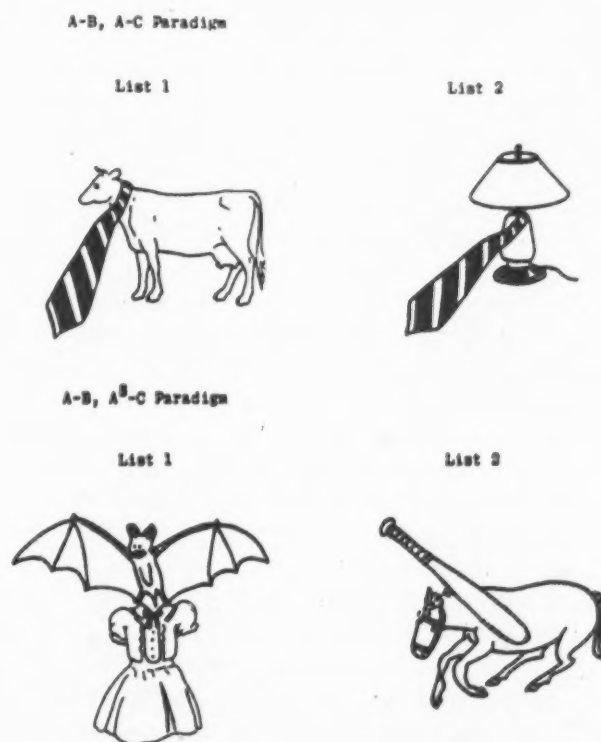


Fig. 12. Examples of materials used for A-B, A-C and A-B, A^S-C paradigms.

is right, then an application of our knowledge about specific transfer effects to the present situation suggests the following: if there is a simultaneous storage of verbal and imagery information by the children in first list learning, then there should be predictable interference patterns in transfer tasks that disrupt that simultaneous store. If, on the other hand, the matter rests on imagery alone and covert verbalization does not accompany imagery, then there should be no interference detected in transfer. We wanted our procedures to provide a strong inducement for the children to perform the simultaneous verbalization-imagery store. Therefore, the experimenter labeled both the stimulus and response pictures. Our assumption here was that the older, and not the younger, children would be capable of performing that simultaneous store. Thus, the specific negative transfer that exists in the semantic change paradigms should hold true for the older child, but not for the younger child. That is to say, the very fact that older subjects apply verbal tags to their meanings or images of multiple-meaning words leads them into an interference situation.

Independent groups of children from the three grade levels performed under two experimental treatments. One of these was an imposed image condition. That is, the pictures were presented in some kind of interaction as shown in Figure 12. A conjunction phrase that labeled the objects accompanied the image; e.g., "The bat and the dress." The second treatment was a sentence condition wherein the subjects were presented side-by-side pictures accompanied by a declarative sentence; e.g., "The bat carries the dress."

The paradigm factor and the semantic frequency factor were manipulated in a 24-item mixed list. The three transfer paradigms were C-D, A-C, and A^S-C. The high and low semantic frequency items had means of .82 and 10 per mille in the Lorge and Thorndike (1938) count. The 24 pairs of pictures in each list were pasted on 6" x 9" cards and bound in three-ring binders.

The subjects participated individually. Prior to first list learning, the task was described and the subjects were given practice from a booklet containing items which pictured geometric figures or numerals.

A study-test recognition procedure was used. For the study portion of each trial, the subject looked at the interacting or side-by-side pictures while the experimenter spoke the appropriate sentence or conjunction phrase. Study time was 5 sec. per pair. During unpaced test, the unlabeled picture of the stim-

ulus was shown, and the subject tapped his response choice with the eraser end of an unsharpened pencil. A vertical 19" x 24" card picturing all 24 response items was within easy reach of the subject who was told specifically to tap his response and not to say the name of the picture.

First list learning criterion was 22/24, and the second list was presented for three study-test trials. Interlist interval was approximately 1 min.

The transfer results for the grades, treatments, and semantic frequency factors are shown in Figure 13. Notice that kindergarten and second grade children produce differentially more errors for low frequency items under imposed imagery. A sentence context, on the other hand, acts in a way that makes low and high frequency items comparable in error rate. What seems to be happening is that the use of a verb in the sentence condition attributes relational meaning to the stimulus and response objects whether they are high or low in semantic frequency. Under the imposed image condition, younger children fail to "read" the relational interaction depicted (Reese, 1970). The items that make up the interacting image are stored as separate and static elements. This is not unlike the observations of Elkind, Koegler, and Go (1964) who found that young children perceive either the whole of a picture or the parts that make up the whole, but not both; i.e., the children see either pieces of fruit or a man when presented with a picture of a man made out of fruit.

The results for transfer paradigms are presented in Figure 14. Tests on these results indicate that kindergarten children produce interference patterns which, in one way, are typical of studies of transfer. That is, their

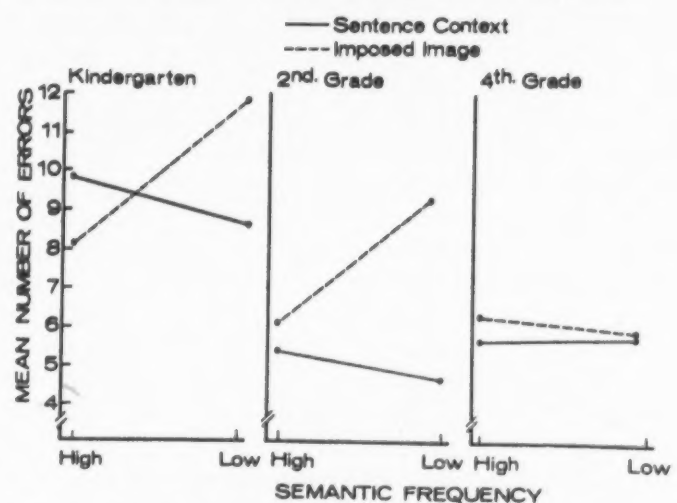


Fig. 13. Within-grade performance for sentence and imagery groups on the semantic frequency measure.

performance on control pairs, C-D, is better than their performance on negative transfer pairs, A-C and A^S-C. At the same time, kindergarten children produce approximately the same numbers of errors in A-C and A^S-C. Thus, for kindergarten subjects, neither imposed imagery nor sentence contexts act to reduce negative transfer.

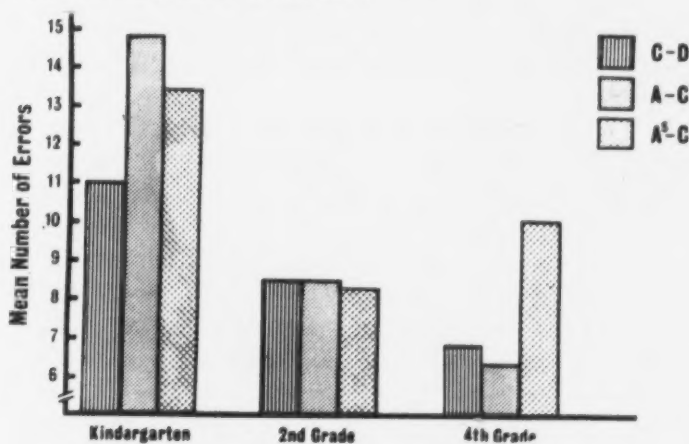


Fig. 14. Within-grade performance on the experimental paradigms.

Consider next the fourth grade performance on paradigms. Here, imposed imagery and sentence contexts reduce negative transfer in A-C relative to C-D. At the same time, fourth grade subjects produce significantly more errors in A^S-C. Thus, the fourth grade subjects of the present study, using pictured pairs, produce interference patterns that are similar to those produced by sixth grade subjects using word pairs (Davidson et al., 1970).

These data are compatible with the Rohwer (1970) theory that a simultaneous verbal-tag and image store is necessary for the efficient use of imagery in single list paired-associate learning. In a transfer situation it is exactly that simultaneous verbalization-imagery store that leads the older subject into a negative transfer situation. Specifically, the application of verbalization tags during second list learning must be responsible for the negative transfer associated with the semantic (image) change paradigms. It is at the time of second list learning that the possibility of a fractionable stimulus term becomes salient (Martin, 1968; Shepard, 1963). Thus, when the subject tags two different semantic items (images) with an identical verbalization, two "storage locations" are signaled and interference results. Furthermore, it would appear that the subject cannot keep his verbalization independent of his imagery under the conditions of interference.

We embarked on this program of research with a variety of strong theoretical arguments for the hypothesis. For example, a thoroughgoing application of the encoding variability hypothesis (Martin, 1968; Shepard, 1963) and a correlative assumption about a "perceptual interpreter" (Bower, 1970) which can "turn off" interference conditions told us to expect no interference under the semantic change paradigms. We did not find that; instead, we found a situation which is more analogous to that described by Kintsch (1970) where encoding cues are not completely independent. Verbalizations intrude into our images, and our images intrude into our verbalizations.

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IV To Find an Appropriate Question¹

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Much of the research that has been done in the name of demonstrating the role of imagery processes in verbal learning is irrelevant to this stated aim. Excluding the work of Paivio (e.g., 1969) on properties of individual words, both the designs of studies and the character of the observations made have been inadequate for making qualitative distinctions among processes. The purpose of this essay is to provide support for these assertions and to propose an alternative question that can provide a use for the information recent research has made available. This will be done by: (a) making a critique of an illustrative imagery hypothesis, that advanced by Rohwer (1970); (b) delineating an alternative hypothesis, to salvage available data; and (c) discussing implications of the alternative for some phenomena of individual differences in learning.

The imagery hypothesis proposed by Rohwer (1970) was intended as an explanation for the results of a number of experiments on noun-pair learning in children. In brief, this proposal can be recapitulated in terms of three propositions: (a) imagery is the mode of internal representation preferred by human beings for storing information; (b) the efficacy of this

mode, as indexed by performance in learning noun pairs, is enhanced when the information is also stored simultaneously in the mode of verbal representation; (c) the capacity for representing information simultaneously in both modes and the inclination to do so increase with age across the range three to ten years. Taken together, these propositions were said to lead to two predictions: that learning conditions designed to promote imagery representation alone will appear more effective the older the subjects sampled; and conditions designed to encourage simultaneous representation in both modes will appear less effective, relative to imagery-promoting conditions, with increasing age. These predictions are, of course, consistent with much of the data reviewed by Rohwer, an unremarkable consistency in view of the fact that these were the data that provoked the formulation of the propositions.

The nagging thing about the hypothesis, however, is that there are also data available that contradict the predictions Rohwer derived from the propositions. Specifically, there are data that do not reveal the predicted interactions with age (e.g., Reese, 1970; Rohwer, Lynch, Levin, & Suzuki, 1967). The apparent unreliability of these interactions leads to the question, What other phenomena are there that are explicated by the hypothesis? The answer is that there are none. Thus, there is little reason to maintain the hypothesis.

It is interesting to consider the circumstances that account for a hypothesis being stripped of its empirical *raison d'être*. In the present case, one feature of the relationship between the hypothesis and the data with which it was initially allied is particularly prominent:

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the most direct implications of the hypothesis were never tested. That is to say, the hypothesis was mainly concerned with the qualitative character of modes of information storage; in contrast, the empirical tests that were marshalled in its support pertained to the quantitative effects on learning efficiency of different ways of presenting materials. Thus, the chain of inference linking the hypothesis with the data was unnecessarily long. Furthermore, there were links missing: no evidence was presented in support of the presumption that presentation modes correspond to storage modes—pictures evoke images, words evoke mental words; no rationale was given for the presumption that storage of information in an imagery mode should result in increased efficiency of learning. Thus the excessively short life accorded to Rohwer's imagery hypothesis is partially accountable in terms of the flimsy relationship between the hypothesis, at its inception, and the data that spawned it.

In view of the demise of the imagery hypothesis as Rohwer formulated it, taken together with a truly substantial amount of data to be explained, it may be worth the effort to start again toward the goal of rationalizing the evidence about developmental interactions as indexed by differences in learning efficiency.

The Task

Most of the data with which I am concerned here have been collected by means of the method of paired associates. More specifically, the task has been that of learning paired-associate lists of noun pairs. Leaving aside properties of the individual nouns in these lists (virtually all have been high-frequency, concrete nouns) the experimental manipulations of interest have pertained to the relationship between the two nouns in each pair. As Levin (Section I) has explained, these manipulations can be classified in a two-way layout where the rows distinguish between methods that are ostensibly verbal in character versus those that are ostensibly pictorial in character, and where the columns refer to the distinction between manipulations of materials as against manipulations of directions as to what the subject is to do with the materials.

These options can be most clearly illustrated in terms of examples. An instance of manipulating materials where the emphasis is pictorial can be found in an experiment reported by Davidson and Adams (1970). Each of the nouns in every pair was represented by a line drawing of an exemplary object designated

by the noun. Then the two objects in each pair could be depicted as isolated from one another or conjoined in some fashion such as a drawing of a football impaled on an arrow. An example of a materials manipulation where the emphasis is verbal appears in a study where each noun pair was presented alone, or in a grammatical context where the nouns were connected by either a conjunction, a preposition, or a verb: ARROW-FOOTBALL; The ARROW and the FOOTBALL; The ARROW through the FOOTBALL; The ARROW impaled the FOOTBALL (Rohwer, 1966).

In general, manipulations of directions to the subjects have aimed at inducing the subject to produce for himself the versions of materials just described. Thus, a subject might be instructed to envision the two objects named by a noun pair as conjoined (pictorial emphasis)—this direction is often referred to as imagery instructions—or to construct a sentence containing the nouns connected by a verb.

Experiments that have included manipulations of these various types have usually produced results demonstrating a positive effect of all four treatments relative to their respective controls (e.g., Bower & Winzenz, 1970; Davidson & Adams, 1970; Jensen & Rohwer, 1965; Rohwer, 1966). Better performance results: from conjoined than from isolated pictures; from verb and preposition connectives than from conjunctions or isolated nouns; from instructions to visualize than from instructions to study; and from instructions to make up sentences than from instructions to study. Thus, ignoring for the moment the complications introduced by characteristics of the subjects sampled, each of these ways of attempting to manipulate the relationship between pair members has been shown to exert a positive effect on learning efficiency.

Some of these same demonstration experiments, along with additional efforts, have included comparisons of the efficacy of the various manipulations. In fact, all but one of the possible pairwise comparisons (within rows and columns) in the two-way layout have been made and reported. Davidson and Adams (1970) contrasted conjoined pictures with preposition connectives (similar contrasts have been reported by Milgram, 1967; Reese, 1965, 1970; and Rohwer, Lynch, Suzuki, & Levin, 1967). Bower and Winzenz (1970) have contrasted sentence and visualization instructions, as have Paivio and Foth (1970). Bean and Rohwer (1970) have reported results from experiments comparing sentence instructions with presented sentences. Although the results of these studies have varied, the important

point to note is that in all of them, the principal observations were made on some index of learning efficiency.

In view of the magnitude of the phenomena these studies have revealed, it seems appropriate to provide a rationale that squares with the dependent variable observed. To do so, however, some prior questions should be faced. First, how shall the task of learning noun pairs be conceived in terms of what the subject must do? The second question is closely related to the first: What has changed in the subject when he has successfully met the criterion of learning a pair? The final question is, What aspect of this internal event or series of events is reflected in the measurement that is made of the subject's performance?

The question of what is learned in paired-associate tasks has a long, if not illustrious, history in the psychology of verbal learning. This will not be reviewed here. Perhaps the most neutral description is that an association is formed between the two members of each pair presented—what is learned is an association. Notice that this description has no necessary implication for the manner in which the pair members are represented internally—whether they are quasi-pictures or quasi-words—they are simply associated. Notice also that the pair members themselves are not the content of learning. The content of learning is the association between the items. There are exceptions to this, of course, as in cases where the individual items must in some sense also be learned as part of the task, but, barring these cases, the content of learning is associations. Furthermore, the "things" associated are internal, that is, mental representations of the pair members. Thus, the task given a subject in a paired-associate experiment is that of rearranging previously acquired mental representations so that they accord with—are isomorphic with—the external arrangement of items. Such an internal arrangement permits the subject to unequivocally identify and respond with a pair member when its mate from the original external list is presented.

Given this conception of the learner's task, it still remains to specify the character of the mental arrangements of items that result in one member of a set activating the other. Another way to phrase the question is: What is the nature of the bond? In one sense, it is not necessary for present purposes to attempt an answer to this question—so deep a theory is not required as yet. On the other hand it may be helpful for the more superficial speculation that we will engage in here, as well as more satisfying, to posit some kind of content for

the bond. Accordingly, let us tentatively assume that the character of the bond is semantic; the learning of a noun pair is thus defined as an increase in the amount of semantic sharing between the pair members.

The implications of formulating the event of learning in this fashion are relatively modest. One implication is that techniques used for indexing semantic relatedness—e.g., word association, semantic differential—should reveal a positive shift for word pairs as a function of degree of learning in a paired-associate task. Another implication is that however the learning of a pair occurs, that is, whether it occurs rapidly or slowly, the semantic shift should be the same. The degree of semantic shift should correlate with the degree of learning but not with the speed of learning. Similarly, there should be no correlation between the method of learning and the degree of semantic shift, provided the degree of learning is held constant; the degree of semantic shift should be the same for anticipation as it is for pairing-test methods, for picture materials as for printed word materials, for ten-second presentation rates as for two-second rates. A final implication is that learning efficiency should be increased by conditions that promote semantic overlap between the pair members in a paired-associate task. This last implication calls for extensive explication, but for now our progress to this point may be summarized as follows: in paired-associate learning, the task confronting the subject is that of investing the two members of each pair with sufficient semantic overlap so as to arrange them mentally in a mutually activating relationship.

Causes of Semantic Shift

No doubt there are many conditions that promote positive shifts toward similarity in the semantic components of initially disparate or unrelated items. These should include the entire range from classical conditioning to hierarchical class inclusion. Here we will focus on only one possibility, namely, that of joint application to the same event. Thus, if any two items are jointly applied by a subject to a single event, they will thereby enjoy an increase in semantic similarity.

As it is, this assertion is sufficiently vague that it advances theorizing very little. In particular, the terms event and joint application must be defined further. An event entails at least two components: one or more objects and one or more occurrences involving an object or some objects. Joint application,

then, denotes decoding the event in terms of the words to be associated.

There is obviously a variety of events that can be signified by such decoding. One of these is the repeated presentation of two words together on a memory drum tape—the two words encode the event of their presentation on the drum within that particular paired-associate list on that particular day. It must be admitted that this rather restricted kind of joint application is responsible for the achievement of mastery of many paired associates for many subjects. The hypothesis proposed here, however, contends that semantic sharing is achieved more readily if the words involved are applied to a single event in such a way as to realize their referential function. The notion is that more semantic sharing is promoted when the referential properties of words join in applying to a single event than when any of their other properties, including especially intraverbal ones, are involved. Accordingly, the hypothesis implies that conditions which promote joint reference to single events should facilitate performance on paired-associate tasks. Note especially the partially hidden stipulation here: the event to which joint reference is made must include components that normally elicit the words to be associated.

Promoting Joint Reference

In order to specify conditions that affect joint reference in paired-associate learning it is necessary to identify segments of the process. One of these is the location of an event such that (a) its principal features can be captured by the two words in a pair, and (b) the two objects denoted by the words are related to one another by the event. This segment of the joint reference process is prerequisite to the second, namely, that of applying the two words to the event, or, if you prefer, encoding the event in terms of the two words. Conditions that insure the accomplishment of both these segments should increase the probability of semantic sharing between the pair members to be associated.

Analytically, the first segment, event location, is by far the most challenging. For any given pair of words, there are some events that will be more productive of successful joint reference than others. The major determinant of the productivity of the event is whether or not it is uniquely defined, for the learner, by the objects denoted by the pair members. If the character of the event, in particular its result, is markedly altered by

substituting an alternative for one of the pair members, then that event should be an effective one for joint reference. On the other hand, if substitution leaves the event largely intact, then it should be relatively ineffective. By way of illustration, consider a pair of words like "rocks-bottle." One relevant event involving the referents of these terms might consist of the rocks smashing the bottle. The present contention, however, implies that this event would be less productive than one in which, for example, the rocks filled the bottle. The reason for this ordering is that both of the terms are integral to the second event—in order to produce a rock-filled bottle, both rocks and a bottle are required—whereas the first event, a smashed bottle, could be produced by any number of things other than rocks, such as an angry drinker. Even so, both of these events should be superior to still a third one like a patch of ground strewn with rocks and a bottle. In this third case, one of the principal features of the event, the ground, is not captured by the terms to be associated and the event does not relate the terms. Both of the first two events meet these criteria. Thus the effectiveness of an event as an occasion for joint reference varies with three factors: that its principal features be denoted by the terms to be associated; that it bring the things denoted into direct relation; and that the identity or product of the event would be changed by substitution of any term other than the two presented.

Having established some preliminary criteria for the expected effectiveness of events, it remains to specify the ways they can be located. Clearly it is necessary that the event be produced by the learner, either directly from memory or by extrapolating from memories and other knowledge. The only issues are how much of the necessary information is available in memory, and how much prompting is required to induce the learner to produce the event. If the optimal event is directly available in memory, then very minimal prompting should be necessary to induce the learner to locate it. If it is not directly available, and the learner has incomplete knowledge of the properties of the objects denoted by the words, then substantial prompting may be necessary. Prompting conditions themselves are probably numerous and require that criteria be specified for their effectiveness—this will be attempted shortly.

The second segment of the joint reference process is relatively straightforward once the optimal event has been produced. In fact, it is only worth mentioning the process of apply-

ing the terms to the event because some kinds of learners, especially young children, are not inclined to do so. One means of inducing this, of course, is to require the learner to overtly apply the terms to some overt representation of the event.

At this point, it is important to emphasize that the present hypothesis does not concern the verbal encoding of a pictorially represented event. The hypothesis does not pertain at all to the means or modality by which the learner internally represents the event he produces. Instead, the implication of the hypothesis is simply that the terms to be associated must be applied to the event produced if it is to eventuate in joint reference.

Prompts to Event Production

It is possible to order conditions that prompt the production of an effective event from very indirect to very direct. Indirect or implicit prompts are those that neither emphasize the referents of the words to be associated, nor suggest the production of an event involving them, nor provide assistance in locating the event. A direct prompt, in contrast, is one that focuses attention on the objects denoted by the words, suggests the production of an event, and provides assistance in locating the event. An example of an indirect prompt is provided by the usual conditions of administering a paired-associate list of printed words where the subject is simply instructed to learn the pairwise arrangement of the list. An example of a direct prompt is a procedure where the pair members are represented by instances of the objects they denote, where an event involving them is enacted during presentation, and where the learner is directed to produce the event himself, either by carrying out the enaction or by reconstructing it internally.

A number of variations around the poles of this dimension of prompt directness have been used in reported experimentation. Around the indirect pole are conditions where pair members are presented as words with the instruction to envision an event or to construct a sentence describing an event. Another variation is that of using object representations of pair members while omitting the event-producing instructions. There are even negative instances where attention is directed to the verbal character of the pair members (e.g., the instruction to spell each word as it is presented) and away from the task of locating and producing an event (e.g., the instruction to repeat the words again and again). Around

the direct prompting pole there are also variations, from enacting events with object referents, through photographic representation of the events, to graphic representation of the product of the event as in a line drawing of the objects denoted by a pair where objects are conjoined as they would be at the terminus of some event.

In general, the more direct the prompt, the higher the probability of joint reference, and, therefore, the more efficient the learning. This prediction should be erroneous only in cases where the provided prompt results in the production of an event that is less effective than that which the subject would have produced in the absence of the prompt. Thus, in some cases, a less direct prompt might result in higher levels of performance than a very complete and explicit one. More will be said about this matter in connection with the topic of individual differences.

A consideration of the second segment of the joint reference process leads to similar conclusions. In general, the greater the degree to which the task procedure requires the overt application of the paired-associate words to the event, the better should be the resulting performance. The exceptions here include those cases where such a requirement detracts from an emphasis on the referents of the terms and from the event that links them.

The conception of learning presented calls for discussion of a number of its implications. It should be related to other conceptions, such as meaningfulness and concreteness, that seek to account for performance differences as a function of materials. It should be explicated further in terms of predictions about item differences and their interaction with prompt effectiveness. The conception should be elaborated further to include accounts of the possible effects of response method on performance. All of these matters, however, will be left for another occasion and the remainder of our discussion will center on the topic of individual differences as it relates to the issue of prompt effectiveness.

Individual Differences and Event Prompts

Let us assume that for every combination of word pair and learner there is a set of events that is optimal for effective joint reference. If so, then for a given word pair there is ample room for interaction between prompting conditions and subject variables. Such interactions should be attributable either to (a) differences

across classes of learners in the probability that a given prompt will evoke the production of an event or to (b) differences in the effectiveness of the event produced. The first source of interaction is likely to be found as a function of subject variables such as chronological age (CA), mental age (MA), and perhaps even cultural differences in the kind of prompt necessary to emphasize the referential property of words. The second interaction source is also likely to emerge across CA and MA groups as well as across cultural groups in connection with differences in learned referential meaning that are correlated with these group differences; the terms to be associated may be appropriate to a given event for one group and entirely inapplicable to that event for another group.

These expected interactions between subject variables and prompt characteristics may be phrased more explicitly in terms of predictions. One set of predictions concerns differences in prompt effectiveness as a function of the subject variable of chronological age: given a maximally effective prompt to event production, coupled with a maximum emphasis on the referential properties of the word pairs, there should be little difference in learning efficiency as a function of age. This prediction is consistent with the results of an experiment reported by Irwin (1971). Three age groups were sampled: kindergarten, second-, and sixth-grade children. The stimulus materials were replicas of objects denoted by the noun pairs in the 32-item list. A variety of prompts were used, all of which (except for the control prompt, i.e., "learn the list") included explicit emphasis on an event involving the two objects in each pair and all of which assisted the subject in locating such an event by presenting it, either through enactment or through verbal description. For example, subjects were shown the pair "plane-bathtub," and the event of the plane landing in the bathtub was either enacted for the subject or was described to him. The results showed that, as compared with the control prompt, the more direct prompts were effective at all three grade levels to approximately the same degree.

A contrasting prediction concerning differences in prompt effectiveness as a function of age is that prompts of low directness will be ineffective in early childhood, especially if used with materials that do not emphasize the object referents of words, whereas in adolescence they will be effective regardless of the manner of representing the words to be associated. Mr. John Eoff (personal communication) recently completed a study designed to

test this prediction. The prompt condition of principal interest was the instruction of directing subjects to envision an event involving the two objects denoted by the words in each pair. The words were represented either by line drawings of the objects they denoted or in orthographic form—in both cases the words were presented aurally. The control prompt consisted of simply instructing the subjects to learn the word pairs. The grade levels sampled were: first, third, sixth, and eleventh. Note that the instructional prompt used here provided the subject no assistance whatever in locating an effective event for joint reference, even though it did emphasize referents and suggest that events be produced. The results were in accord with the prediction: as compared with the control prompt, the instructional prompt was ineffective in the first-grade sample for both word and picture conditions, in the third grade it was effective only for the picture condition, and in the sixth and eleventh grades, it was effective for both conditions.

The results of both the Irwin and Eoff experiments thus provide modest corroboration of predictions derived from the hypothesis proposed here. An examination of the results of some additional studies reported elsewhere in this paper (Levin, Section I; Wolff, Section II) also appear to be consistent with the hypothesis. But what of predictions concerning differences in prompt effectiveness as a function of cultural differences? A portion of a recent experiment by Guy (1971) is pertinent to a combination of predictions about cultural and developmental differences. Reasoning that the referential meaning of words presented in a school-like setting is a less prominent feature for low-SES black children than for high-SES white children, it was predicted that the two groups would differ in paired-associate performance when noun pairs were presented aurally but not when represented by line drawings of their referents. Furthermore, it was predicted that this outcome would obtain in a sixth-, but not in an eleventh-grade sample. The rationale for the latter prediction was that for the older subjects, the predominant determinant of performance differences would be event production rather than object reference since both samples should respond to the referential aspect of the words. Thus the major predictions pertained to performance in a minimal prompt condition—instructions to learn the word pairs. Even so, if the predictions were correct, the expected difference between samples at the eleventh-grade level given a control prompt was expected to disap-

pear when a more direct event prompt was used. The latter prompt consisted of a verbal event description in the word condition and a line drawing of the two object referents as conjoined in some way in the picture condition. The results were consistent with the predictions: the only significant performance difference between the two samples at the sixth-grade level was in the aural condition with control prompts. At the eleventh-grade level, both aural and picture conditions revealed a population difference with control prompts but not when the more direct event prompts were provided.

This brief review of studies relevant to the hypothesis offered here is not advanced as compelling evidence in its favor. The results thus far do provide some encouragement, even though they are preliminary at best. For

example, the question of individual differences in prompt effectiveness within age and cultural groups has barely been addressed to date. Levin, Rohwer, and Cleary (1971) have reported some data consistent with the notion that there are reliable individual differences in the extent to which aurally-presented words evoke object reference. Similar analyses of the relative effectiveness of more direct prompts must also be made before the present hypothesis can be regarded as a useful or a fruitful one. Nevertheless, in its favor, note that the hypothesis does account for some available data and that it does so directly in terms of the kinds of measurements that have been taken rather than attempting to stretch efficiency observations to make distinctions between the modality of hypothesized internal processes.

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